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FOR REVIEW PURPOSES ONLY

UNITED STATES DEPARTMENT OF AGRICULTURE
WAR FOOD ADMINISTRATION

POST-WAR READJUSTMENTS IN THE PROCESSING AND MARKETING OF FIBER CROPS

Part of a proposed report on
POST-WAR READJUSTMENTS IN PROCESSING AND MARKETING
FACILITIES AND METHODS
To be submitted to
THE INTER-BUREAU COMMITTEE ON POST-WAR PLANNING
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FOREWORD

The several agencies making up the Department of Agriculture and War Food Administration are cooperating in a program of post-war planning, under the general direction of Secretary Wickard and an inter-bureau committee. The work in marketing consists of 10 projects dealing with such problems as the liquidation of wartime food regulations, post-war price supports, surplus marketing programs, and readjustments in processing and marketing facilities and methods. This report is one of several to be issued as part of the latter project. It indicates the potential post-war marketing situation that will face growers of cotton and other natural fibers produced in this country. It was prepared largely by the following staff: J. W. Wright, C. C. McWhorter, and L. J. Watson, Cotton and Fiber Branch, Office of Distribution; R. J. Cheatham and R. B. Evans, Southern Regional Research Laboratory, Bureau of Agricultural and Industrial Chemistry; and Maurice R. Cooper, Bureau of Agricultural Economics.

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POST-WAR READJUSTMENTS IN THE PROCESSING AND MARKETING OF FIBER CROPS

INTRODUCTION

Present indications are that post-war markets for American fiber crops will be affected very materially by technological and other developments in the processing and marketing of textiles and other products that have occurred as a result of or that have been accelerated by the war. The partial or complete displacement of natural fibers by synthetic fibers for certain uses may result from the unprecedented impetus that has been given to the expansion of production facilities for the synthetic fibers for war uses. On the other hand, new or expanded markets for the natural fibers may be provided in connection with new products and processes that are now in process of development.

An appraisal of the extent to which readjustments may be necessary in the processing and marketing of fiber crops as a result of the technological developments that have been initiated or accelerated by the events of the war, can, perhaps, best be made on the basis of an analysis of the situation with respect to:

1. Trends in the consumption of the principal fibers preceding the war and during the war period.

2. Recent developments in connection with some of the principal specific uses for fiber crops.

3. Probable post-war developments.

TRENDS IN CONSUMPTION OF PRINCIPAL NATURAL AND SYNTHETIC FIBERS

Mill consumption of raw fibers in the United States has been at the highest rate in history during the last 4 years (1940-43), with quantities used running 48 percent higher than during the preceding 5 years of 1935-39. In all, an average of about 7.0 billion pounds of fiber was consumed per year during 1940-43 as compared with 4.3 billion pounds annually during the World War I years of 1915-19, 3.7 billion pounds annually during the depression period of 1930-34, and about 4.8 billion pounds in the pre-

war period of 1935-39 (table 1). Peak consumption of fibers was in 1941 when about 7.7 billion pounds of fibers were consumed. Since then, consumption has declined successively to about 7.2 billion pounds in 1942 and 7.0 billion pounds in 1943. This decline is generally associated with the textile industry's shortages of manpower and with its inability to replace worn out machinery with new equipment.

On a per capita basis, annual consumption of fibers has also been at record levels during the last few years. Consumption of fibers per person has averaged 52.5 pounds during 1940-43 as compared with only 41.8 pounds during World War I. On the other hand, it should be noted that the quantity consumed per person just prior to the present war (1935-39) was less than during 1910-19 and 1925-29 (table 1).

The main reliance for meeting the United States' need for textile fibers is now, and for many years has been, on one fiber -- cotton. During the pre-war period from 1935-39, cotton consumption averaged 3,490 million pounds. This represented about 72 percent of all fiber used in this country during that period. With the coming of the war, consumption increased to record levels. The peak was reached in 1941 at 5,470 million pounds (11.2 million bales). It is expected that the quantity consumed during the 1943-44 cotton year will not exceed 5,060 million pounds (10.3 million bales). During the war years of increased fiber consumption, cotton has held its place and has comprised about 73 percent of all fibers used (table 2).

Consumption of wool also has been at record levels since the beginning of the war in 1939 but, as with cotton, was at a peak in 1941 (648 million pounds). It has declined to a total of about 592 million pounds for 1943.

Consumption of rayon has continued its long-time upward trend with the total of 656 million pounds for 1943, the highest on record. The increase in the consumption of rayon in the United States during the last 10 years has been more than fourfold. World consumption has shown more than a sevenfold increase in the same period. In terms of cotton equivalent, world consumption of rayon in 1932 was equal to about 1-1/4 million bales of cotton, while 1942 consumption was equivalent to about 8 million bales.

Silk has never been of great importance quantitatively, but consumption has been at a minimum since imports from Japan ceased in 1941. Rayon has taken its place to a large extent.

Quantities of flax and mohair consumed have increased only slightly since the beginning of the war.

Table 1. - Mill consumption of raw fibers in the United States during specified periods, 1910-43

Period 1/	Cotton	Wool	All others 2/	Total
	Million pounds	Million pounds	Million pounds	Million pounds
Total:				
1910-14	2,446	297	796	3,540
1915-19	2,974	386	908	4,268
1920-24	2,821	378	751	3,950
1925-29	3,292	365	848	4,505
1930-34	2,687	285	730	3,702
1935-39	3,409	377	972	4,758
1940-43	5,150	563	1,323	7,036
Percentages of total:	Percent	Percent	Percent	Percent
1910-14	69.1	8.4	22.5	100.0
1915-19	69.7	9.0	21.3	100.0
1920-24	71.4	9.6	19.0	100.0
1925-29	73.1	8.1	18.8	100.0
1930-34	72.6	7.7	19.7	100.0
1935-39	71.7	7.9	20.4	100.0
1940-43	73.2	8.0	18.8	100.0
Per capita 3/:	Pounds	Pounds	Pounds	Pounds
1910-14	25.7	3.1	8.4	37.2
1915-19	29.1	3.8	8.9	41.8
1920-24	25.7	3.4	6.8	35.9
1925-29	27.9	3.1	7.2	38.1
1930-34	21.5	2.3	5.8	29.7
1935-39	26.4	2.9	7.5	36.9
1940-43	38.4	4.2	9.9	52.5

1/ Data compiled by calendar years.
2/ Including rayon, silk, flax, jute, hemp, and various hard fibers. Includes small quantities of mohair 1935-43, but mohair is included with wool for 1910-34.
3/ Total divided by average population.

Table 2. - Mill consumption of designated raw fibers in the United States, 1935-43

Year 1/	Apparel fibers: Cotton 2/	Wool 3/	Silk 4/	Rayon 5/	Flax 6/	Mohair 6/	Total	Other fibers: Jute 4/	Hemp 6/	Hard fibers 4/	Total	Grand total
	Mil. lbs.	Mil. lbs.	Mil. lbs.	Mil. lbs.	Mil. lbs.	Mil. lbs.	Mil. lbs.	Mil. lbs.	Mil. lbs.	Mil. lbs.	Mil. lbs.	Mil. lbs.
Quantities:												
1935	3,102.1	417.5	72.4	259.3	12.6	14.8	3,878.7	146.8	2.7	404.6	544.1	4,432.8
1936	3,883.8	406.1	67.5	322.6	13.3	16.3	4,709.6	176.2	2.7	399.8	578.7	5,288.3
1937	2,855.2	380.8	64.2	304.7	14.2	16.6	3,635.7	265.7	2.8	422.2	690.7	4,326.4
1938	3,372.1	284.5	57.0	329.4	3.1	15.2	4,061.3	102.1	2.5	320.1	424.7	4,486.0
1939	3,833.2	396.5	55.3	458.7	14.2	17.8	4,775.7	80.3	2.8	398.1	481.2	5,256.9
Av.'35-39	3,409.3	377.1	63.3	334.9	11.5	16.1	4,212.2	154.2	2.7	389.0	543.9	4,758.1
1940	4,750.7	407.9	47.6	482.0	11.4	17.7	5,717.3	107.9	2.3	479.9	590.1	6,307.4
1941	5,470.2	647.9	25.6	591.7	11.0	18.8	6,765.2	233.8	7.4	656.9	898.1	7,663.3
1942	5,318.0	603.6	--	620.6	19.2	17.9	6,579.3	128.2	18.7	433.5	580.4	7,159.7
1943 7/. . .	5,060.0	591.9	-	656.1	12.5	8/	6,320.5	225.0	136.0	310.0	671.0	6,991.5
Av.'40-43	5,149.7	562.8	18.3	587.6	13.5	18.1	6,345.6	173.7	41.1	470.1	684.9	7,030.5
Percentage of total:	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.	Pct.
1935-39 . .	71.7	7.9	1.3	7.0	.2	.3	88.5	3.3	.1	8.2	11.5	100.0
1940-43 . .	73.2	8.0	.2	8.3	.2	.3	90.2	2.5	.6	6.7	9.8	100.0
1943 . . .	72.4	8.5	-	9.4	.2	8/	90.4	3.2	1.9	4.5	9.6	100.0

1/ Calendar years except for cotton which is given for years beginning August 1.
2/ On basis of consumption and bale weight data reported by Bureau of Census.
3/ Consumption on scoured basis as reported by Bureau of Census.
4/ Imports for consumption as given in foreign trade statistics.
5/ Deliveries of rayon manufacturers plus imports for consumption as given by Rayon Organon. Subsequent to October 1941, imports not included.
6/ Domestic production as reported by Department of Agriculture plus imports for consumption.
7/ Preliminary.
8/ Not available. Assumed to total 17.9 million pounds for totals and percentages.

Imports of raw jute fell off in 1942 because of war conditions. Consequently consumption dropped as our entire supply is imported. But with improved shipping conditions in 1943, it has been possible to bring in larger quantities of jute and jute products.

Imports of hard fibers increased to record levels in 1941, as efforts were made to build stockpiles in this country, but since have declined as a result of the Japanese occupation of principal production areas in the Philippine Islands and Dutch East Indies.

Available supplies of hemp were many times greater in 1943 than during any other recent year, as a result of the Government hemp program. It is expected, however, that domestic production will decline in 1944 and will eventually drop back to its pre-war level when the hard fibers from foreign sources become available again in quantity.

In addition to the fibers discussed in the foregoing, small quantities of synthetic fibers, several recently developed, are being produced and used. Included in this group are nylon, vinyon, and saran (all derived from synthetic resins), glass fiber, casein fiber, and soybean fiber. Production of nylon was on a pilot plant scale until the close of 1939 when it was increased to a rate of about 4 million pounds per year with completion of the first commercial plant. Thereafter successive increases were made in the facilities until the capacity was large enough to provide about 20 million pounds per year by 1942. Production of vinyon has been very small because of shortages of raw materials. Production of saran for weaving purposes was reported to total about 1 million pounds in 1943 and slight additional quantities were produced for use in cordage. Casein fiber was introduced in about 1940 and the production rate is now about 8 million pounds per year. Soybean fiber is yet in a pilot plant stage, with experimental production totaling not more than about 5,000 pounds per day.

COTTON

DEMAND FOR COTTON AS INFLUENCED BY COMPETITION FROM SYNTHETIC FIBERS

Although many other fibers compete with cotton in various uses, rayon is the fiber that has competed most intensively with cotton and has displaced it most in recent years. This competition is continuing at the present time and is a highly important factor in the future outlook for cotton. Other synthetic fibers have been on the market only a short time and as yet have competed with cotton to only a minimum extent. They will be of increasing importance, however, in the future.

Development and Use of Rayon

Uninterrupted manufacture of rayon (synthetic fibers whose basic raw material is cellulose) in the United States did not begin until 1910, but since then production has increased steadily and rapidly until now more rayon is used in this country than any other fiber except cotton. This progress is attributable very largely to continuing improvement in the quality of rayon and to a downward trend in its price.

At first rayon was of low tensile strength and highly irregular in quality, with poor wearing performance and poor resistance to moisture. But these properties have improved steadily, with the result that rayon has become satisfactory for an increasing number of uses. At the same time, the number of types, sizes, and forms in which it is available has continued to increase, making possible substantial progress in the adaptation of rayon to the requirements of individual uses.

In this country until after World War I, all rayon was made by the viscose process but since then other processes have been introduced, most important of which is the acetate process. Chemically, acetate rayon is an acetate ester of cellulose instead of regenerated cellulose as is viscose rayon, and has distinctly different properties than the latter. Production of acetate rayon has been increasing at a faster rate than the production of viscose rayon and it now comprises about 28 percent of all rayon manufactured in the United States as compared with 71 percent viscose and about 1 percent cuprammonium.

Another development that has greatly extended rayon's field of use in the last few years has been that of rayon staple fiber. Until about 1927, all rayon produced in the United States was filament rayon, or rayon made of continuous filaments or fibers similar to silk. About that time, rayon staple fiber, or rayon cut into short lengths comparable to cotton and wool, was introduced commercially. Staple fiber costs less to produce per pound than continuous filament rayon because of lower handling costs, and can be spun on cotton and wool spinning equipment, which comprises the great majority of the textile spinning facilities of the country. By using it, entirely different types of fabrics with different properties can be obtained than by using continuous filament rayon. Rayon staple fiber now comprises 24 percent of all rayon produced in this country (table 3).

Still another important development in rayon manufacture during the last few years has been high-tenacity or high-strength rayon. High-tenacity rayon is considerably stronger than ordinary rayon and makes possible the use of rayon in tire fabrics and other applications for which rayon formerly was not suited. Production of high-tenacity rayon is being expanded rapidly at the present time.

Table 3. - Production of rayon filament yarn and of rayon staple fiber in the United States, 1910-43

Year	Filament yarn		Staple fiber		Total	
	Million pounds	Percent	Million pounds	Percent	Million pounds	Percent
Average:						
1910-14 . . .	1.1	100.0	-	-	1.1	100.0
1915-19 . . .	6.1	100.0	-	-	6.1	100.0
1920-24 . . .	24.1	100.0	-	-	24.1	100.0
1925-29 . . .	81.6	99.9	0.1	0.1	81.7	100.0
1930-34 . . .	166.9	99.2	1.3	.8	168.2	100.0
1935-39 . . .	288.6	92.4	23.7	7.6	312.3	100.0
Total:						
1940	390.1	82.8	81.1	17.2	471.2	100.0
1941	451.2	78.8	122.0	21.2	573.2	100.0
1942	479.3	75.8	153.3	24.2	632.6	100.0
1943	501.1	75.6	162.0	24.4	663.1	100.0

Compiled from Rayon Organon, Special Supplement, January 21, 1944. Filament yarn production shown began in 1911, staple fiber production in 1928.

Reduction in Price

A marked downward trend in price has also made possible the use of rayon for an increasing number of textile applications. Prices of rayon filament yarns declined steadily after World War I until about 1934, with quotations for the heavily used 150 denier viscose size falling from an all-time peak of $6.00 per pound in 1920 to $2.80 in 1922 and 1923, $1.25 in 1929, 60 cents in 1932, and 55 cents in 1934. Since 1934, prices have remained comparatively stable, with quotations for this size fluctuating from as high as 63 cents per pound (1937) to as low as 49 cents (1938), and remaining at 55 cents since November 1941. Prices of rayon staple fiber have also declined considerably since this type of rayon was introduced, with quotations for viscose staple fiber declining steadily from 60 cents per pound during 1928-31 to 25 cents per pound in 1937. A further reduction to 24 cents per

pound was made in May 1943, but the price was returned to 25 cents per pound in March 1944. Unlike prices of cotton and other fibers, there has been no increase in rayon prices since the beginning of the war. Consequently, rayon today is in a better competitive position, from a price standpoint, than at any other time since it was introduced.

Displacement of Cotton by Rayon

Consumption of cotton, wool, silk, and rayon during the years 1935-43 is given in table 4. As is indicated, consumption of rayon has more than doubled since 1935 and now comprises 10 percent of the total consumption of these fibers as compared with 7 percent during 1935-37. Despite this increase, far more cotton and wool were used in 1943 than during the pre-war years, and there is thus no evidence from these statistics that cotton or wool has been displaced by rayon. Undoubtedly, consumption of cotton and wool would have been greater, however, if rayon had not been available.

Until recently, practically all rayon was used for style fabrics - that is, in fabrics where appearance, draping qualities, and other style characteristics are the competitive factors of greatest importance. Such uses are found principally in the field of clothing, particularly women's clothing, and in household furnishings. Accurate statistics relating to rayon's invasion of these fields are not available, but it is well known that rayon has displaced cotton to a considerable extent in articles such as women's dresses and underwear, and that it is in competition with cotton in hosiery, table cloths and napkins, and other goods. This trend is continuing at the present time, with rayon now entering such uses of cotton as men's underwear and shirts, men's summer suits, handkerchiefs, and other items. Development of high-tenacity rayon has removed one of the barriers to use of rayon in industrial textiles and certain other uses where high strength is needed, and as a result, rayon now is also being used in such articles as tires, parachutes, and self-sealing gasoline tanks.

Probable Post-War Trends

For the immediate post-war period, a continued rise in the domestic production of rayon and other synthetic fibers may be expected on the basis of plans already being carried out by manufacturers. There undoubtedly will be further displacement of cotton by synthetic fibers in certain uses, particularly those involving cotton textiles of high quality and of a high-

Table 4.- Consumption of designated textile fibers in the United States, by calendar years, 1935-43

Year	Cotton 1/	Wool 2/	Rayon 3/	Silk 4/	Total
	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds
1935	2,752	418	259	72	3,501
1936	3,466	406	322	68	4,262
1937	3,627	381	305	64	4,377
1938	2,932	284	329	57	3,602
1939	3,625	396	459	55	4,535
Average 1935-39	3,280	377	335	63	4,055
1940	3,969	407	482	48	4,906
1941	5,175	648	592	25 5/	6,440
1942	5,614	604	621	6/	6,839
1943	5,279	640 7/	656	6/	6,575
	Percent	Percent	Percent	Percent	Percent
1935	78.6	11.9	7.4	2.1	100.0
1936	81.3	9.5	7.6	1.6	100.0
1937	82.9	8.7	6.9	1.5	100.0
1938	81.4	7.9	9.1	1.6	100.0
1939	80.0	8.7	10.1	1.2	100.0
Average 1935-39	80.9	9.3	8.3	1.5	100.0
1940	80.9	8.3	9.8	1.0	100.0
1941	80.3	10.1	9.2	.4	100.0
1942	82.1	8.8	9.1	-	100.0
1943	80.3	9.7	10.0	-	100.0

1/ From reports of Bureau of the Census. Pounds equal bales consumed multiplied by average net weight of bales produced during 12 months preceding August 1 of year designated.
2/ Carpet and apparel class, scoured. From Bureau of the Census reports.
3/ From Rayon Organon.
4/ Imports for consumption of silk and silk waste.
5/ January - September only.
6/ Data not available but probably nominal.
7/ Preliminary.

unit value, but any change will be gradual and is likely to be of little immediate importance as compared with general business conditions. The present war has hastened the large-scale production of high-tenacity rayon, and there is little doubt that there will be increased use of this product in industrial and other textiles. As concluded in the section on tire fabrics which follows, rayon can be expected to hold part of the market for textiles in tires after the war, but the full effect of its displacement of cotton will not be felt until the immediate post-war demand for tires subsides.

The immediate post-war period will, no doubt, see the real entrance of nylon and other new synthetic fibers into many textile uses now supplied by other fibers. Because of the price involved and the limited volume in which they are available, however, they should not be an important factor in the outlook for cotton in the near future.

Technological progress in development and improvement of synthetic fibers can be expected to continue at a rapid rate in the future, in view of the research now being devoted to this subject, and the general rate of scientific progress. At the same time, it can be expected that further reductions will be made in the prices of synthetic fibers, particularly in the prices of the newer types, as economies are effected from mass production and improved technology. Considering these factors it can be expected that the upward trend in production of synthetic fibers will continue.

The extent to which synthetic fibers eventually will displace cotton is difficult to predict. It will depend, to a far greater extent in the future than it has in the past, on which gives the greatest value per unit of cost. Both price and physical suitability are involved here, and both can be influenced by research. At least part of the eventual outcome in the battle between synthetic and natural fibers will depend upon the relative attention given to research by proponents of the two types of materials. It will also be influenced to a considerable degree by promotional activities, particularly in clothing and household uses.

It seems unlikely that cotton will be superseded in the forseeable future as the Nation's most important textile fiber, in view of probable future costs of producing cotton and synthetic fibers and in view of the cost and other requirements of various textile uses. It can be expected, nevertheless, that synthetic fibers will displace cotton in additional uses.

DEMAND FOR COTTON AS INFLUENCED BY COMPETITION OF PAPER

Less than 10 percent of the total paper consumed in the United States is used for products that compete directly with cotton. Paper, nevertheless, is one of the most important competitors of cotton from the standpoint of the quantities of cotton that it has displaced in recent years. This competition has been particularly severe in products such as bags, towels, handkerchiefs, napkins, window shades, plastics, and twine, products which normally account for about one million bales of cotton annually (table 5).

Table 5. - Consumption of cotton in several uses affected by competition from paper, 1939

Use	1,000 bales
Bags	473
Towels	300
Handkerchiefs	30
Window shades	29
Napkins	2
Twine	166
Plastics	10

Based on data in "Cotton Counts Its Customers" and Census of Manufactures.

As is indicated in table 6, consumption of paper in products that compete with cotton has increased rapidly during the last 15 years. Whether it will persist and whether additional quantities of cotton will be displaced in the future is a question that is of obvious importance to growers and processors of cotton. Since the factors involved in an answer to this question vary somewhat with each product, the products will be discussed separately.

Table 6. - Consumption of paper in designated products that compete with cotton, specified years, 1929-43

Product	1929	1935	1937	1939	1943
	1,000 tons	1,000 tons	1,000 tons	1,000 tons	1,000 tons
Bags, Kraft	437	511	668	762	834
Facial tissues and handkerchiefs	1/	20	37	51	60
Napkins	28	46	64	64	76
Towels	52	61	102	141	147
Gummed paper tape	28	30	41	52	57

1/ Not reported separately.
Figures for 1929-39 are based on data from Census of Manufactures and are estimated in part. Figures for 1943 are from industry associations except for bags and napkins, which are production totals for bag paper and napkin stock from Bureau of the Census.

Effect of Competition from Paper in Bags

Cotton fabric, burlap, and paper have all been used for making bags for many years, but paper bags were generally used only for small retail packages until after World War I. The real beginning of a shift from cotton fabric bags to paper bags occurred following the development of the multiwall kraft paper bag in 1924. This development made it possible to use paper for larger-size bags for wholesale shipments of commodities such as cement, fertilizer, chemicals, etc. At the same time, there has been a trend toward use of smaller, consumer-size packages for foodstuffs that has resulted in increased use of paper. Adequate statistics illustrating the displacement of cotton by paper in bags are not available, but trends toward increased use of paper in packaging several important commodities are indicated in table 7.

Table 7. - Approximate percentages of total cement, flour, refined sugar, and fertilizer packaged in various types of containers in the United States during specified years

	Cotton bags 1/	Burlap bags 1/	Paper bags	Other containers	Bulk	Total quantity 2/	
	Percent	Percent	Percent	Percent	Percent	1,000 tons	Percent
Cement 3/							
1925	83	4/	10	-	7	29,572	100
1930	57	4/	30	-	13	29,903	100
1935	38	4/	42	-	20	14,144	100
1939	35	4/	44	-	21	23,058	100
1940	32	4/	42	-	26	24,506	100
1941	29	4/	40	-	31	31,478	100
1942	27	4/	31	-	42	34,836	100
Flour							
1934	68	19	12 5/	1	-	9,580	100
1941	67	19	13 5/	1	-	10,387	100
Sugar, regined							
1930	90	6/	3	7	-	6,039	100
1934	84	6 6/	5	5	-	6,034	100
1940-41	59	10 6/	31	7	-	7,198	100
Fertilizer							
1928	2	98	-	-	-	7,985	100
1937	12	82	6	-	-	8,189	100
1940-41	24	61	15	-	-	7,839	100
1943 7/	25	32	43	-	-	10,000	100

1/ Including both new and second-hand bags.
2/ Based on shipments of cement, production of wheat flour, disappearance of refined sugar, and consumption of fertilizer.
3/ Partially based on data given in Minerals Yearbook.
4/ Small percentages of burlap bags used during most years are included with cotton.
5/ Includes cartons.
6/ A total of 50 percent in burlap bags in 1930, 28 percent in 1934, and 15 percent in 1941, included with cotton bags since they were lined with cotton.
7/ Rough preliminary estimate.

With exception noted, percentages are estimates based on original surveys conducted by the Department of Agriculture.

Since the beginning of the war, use of burlap in bags has been considerably restricted because of reduced imports from India, the source of practically our entire supply of this fabric. In order to replace burlap, consumption of both cotton fabrics and paper for bags has greatly increased. As indicated in table 8, consumption of cotton fabrics in bags was 73 percent greater, and consumption of paper 54 percent greater, in 1943 than in 1940, while consumption of burlap had declined 33 percent during the same period

Table 8. - Estimated quantities of cotton fabric, burlap, and paper used in bags during 1940-43

Year	Cotton fabric		Burlap		Paper 1/	
	Quantity	Index 2/	Quantity	Index 2/	Quantity	Index 2/
	Million yards	Percent	Million yards	Percent	1,000 tons	Percent
1940	819	100	600	100	195	100
1941	844	103	620	103	206	106
1942	1,196	146	306	51	280	144
1943	1,416	173	400	67	300	154

1/ Multiwall bags only.
2/ 1940 equals 100.
Partially based on estimates from War Production Board and from industry associations.

Despite the marked increase in consumption of cotton fabrics, there has been further displacement of cotton by paper in bags since the beginning of the war. This has been notable in the packaging of sugar and rice, where rationing and price regulations have favored the use of smaller bags than heretofore. The increase in the consumption of cotton fabric in bags has been due almost entirely to temporary replacement of burlap and to increased total packaging requirements; whereas much of the increase in use of paper represents permanent changes in packaging methods.

Paper has been adapted for packaging an increasing number of commodities since the beginning of the war, and it is reported that 325 different commodities were thus packaged in 1942. Probably the most important technological advance has been improvement in the resistance of paper bags to moisture. Other than this, the most important progress has been the adaptation of paper bags to additional packaging requirements.

Factors Influencing Use of Cotton and Paper in Bags

As a result of the improvements that have been made during recent years in paper bags, it is now technically possible to use them for many requirements for which only textile bags were suited formerly. With some exceptions, however, paper is not regarded as satisfactory for bags of greater than 100 pounds capacity, and practically all bags for carrying greater loads are made of cotton or burlap. Breakage losses are generally greater if paper bags are used, but this is offset by the fact that losses from sifting and from residues clinging to the bag when it is emptied are often greater for textile bags than for paper bags. With these limitations, and a further limitation that each type of bag is especially suited for certain special requirements, competition between cotton fabrics and paper in bags is almost entirely a matter of cost. Generally speaking, paper bags have a considerably lower initial cost than cotton bags of the same size, but this advantage is often offset by the fact that, unlike fabric bags, they have little or no re-use or salvage value. Fabric bags, on the other hand, are often used over and over again to package either the same or another commodity, or they have considerable salvage value because of the fabric involved. Value for re-use and salvage purposes varies considerably with the type and size of bag, and also with the commodity packaged and the kind of use. There has probably been greater re-use of cotton bags since the beginning of the war than ever before, because of the shortage of new bags.

Although cotton bags often have a higher re-use value than paper bags, this value is not always a factor in determining the type of bag used. Whether it does or does not depends to a considerable degree on how the commodity is sold and handled, how far the ultimate user is removed from the original bag purchaser, and whether there is an organized market for the used bags.

Another cost factor entering into the choice between types of bags is that different equipment is required to package a commodity in paper bags than in cotton bags. This factor reacts to the advantage of the type of bag already being used.

As already mentioned, the trend toward use of smaller-size packages has reacted in favor of paper, since the relative advantages of using paper are greater for smaller packages than for larger ones. This trend has been offset to some extent during the war because of the fact that shipments of flour, sugar, and other commodities for military and lend-lease needs are generally in bulk quantities.

Post-War Outlook for Cotton in Bags

The present unprecedented demand for cotton in bags can be expected to subside as shipments of burlap from India increase. On the other hand, use of fabric bags for shipments to military units and for lend-lease purposes can be expected to continue until sometime after the war. Although paper has made some permanent gains at the expense of cotton during the war, it is not entirely certain that all of these gains will be permanent. Much will depend, of course, on the relative cost of fabric and paper bags after the war. Taking these factors into consideration, it can be expected that use of cotton in bags during the first post-war year or two will be somewhat in excess of pre-war totals, but probably will not exceed the total used in 1943.

Effect of Competition from Paper in Other Products

Consumption of paper in towels increased nearly threefold from 1929 to 1939 (table 9). It is likely also that there was a further slight increase from 1939 to 1943. Despite this increase, production of cotton towels was considerably greater in 1939 than in 1929, and available statistics indicate that there has been no further downward trend of a permanent nature during the years since 1939.

Probably the most important use of paper towels is in public washrooms, where there is a distinct advantage in having low-cost towels for one-use service. Paper towels already have displaced cotton towels in this use to the extent that cotton towels are now not often seen. In addition, paper towels are used to some extent in homes for use in the kitchen and use for this purpose apparently is increasing. With this exception cotton towels have retained their position for use in the home and for similar requirements in hotels, hospitals, and elsewhere.

Table 9. - Quantity of cotton towels produced and consumption of paper in towels, 1929-43

Year	Cotton towels produced 1/	Paper consumed in towels 2/
	Million pounds	1,000 tons
1929	71.0	52
1935	78.3	81
1937	92.7	102
1939	113.1	141
1940	3/	84
1941	119.0	99
1942	96.0	160
1943	3/	148

1/ Towels, toweling, washcloths as reported in Census of Manufactures for 1929-39 and by War Production Board for 1941 and 1942.

2/ Estimated (1929-39) for entire industry on basis of figures given in Census of Manufactures. Data for 1940-43 from The Tissue Association.

3/ Data not available.

Unless there are marked changes in the characteristics of paper towels, little further displacement of cotton towels by paper towels can be expected. Although there may be further displacement of fabric towels for certain special requirements, the total displacement involved should be small as compared with the total market for cotton towels.

Paper handkerchiefs and facial tissues are relatively new products but production was increasing rapidly at the time of our entrance into the war. Quantities of paper used in facial tissues and handkerchiefs increased from 20,000 tons in 1935 to 95,000 tons in 1941 (table 10). Since then, quantities consumed have declined somewhat, no doubt due to wartime shortages of wood pulp. Comparative statistics for cotton handkerchiefs are not available, but about 35 million dozen handkerchiefs were manufactured in the United States in 1939 as compared with about 40 million dozen in 1929. These quantities would require roughly 30,000 and 34,000 bales of cotton respectively.

Table 10. - Quantities of paper consumed in facial tissues and handkerchiefs, United States, 1935-43

Year	1,000 tons	Year	1,000 tons
1935	20	1940	70
1937	37	1941	95
1939	51	1942	62
Average (1935, 1937, 1939)	36	1943	60

Based on data from Bureau of the Census (1935-39) and from The Tissue Association.

There is no question that paper handkerchiefs and facial tissues are directly competitive with cotton handkerchiefs and cotton wash cloths, and that their use results in displacement of cotton. As with other paper products, paper handkerchiefs and facial tissues are available at a small fraction of the cost of comparable fabric products, but can be used only once. Advertising for the paper products stresses the advantage of using a "disposable" paper tissue for colds. On the other hand, paper handkerchiefs are not suitable for carrying on one's person as cotton handkerchiefs are.

On the basis of available information it seems likely that there will be further increases in the consumption of paper handkerchiefs and facial tissues. This prediction is made on the assumption that markets for these products, in types of use where they possess advantages, have not been fully exploited. There, nevertheless, seems to be little likelihood that cotton will be entirely displaced in this use, or that any substantial market for cotton will be involved.

Production of paper napkins, another paper product in competition with cotton, also had increased rapidly during the 10 years preceding the war (table 11). A peak was reached in 1941, after which the quantity of paper produced for this purpose declined slightly, no doubt because of wartime shortages of paper. Statistics indicating trends in the production or consumption of cotton napkins are not available but some idea of the quantities involved may be gained from the fact that 1,043,899 dozen fabric

napkins were manufactured in the United States during 1939. The great majority of these napkins were probably cotton, and it is estimated that this quantity would require about 2,000 bales of cotton. In addition 779,000 dozen linen napkins were imported during 1939.

Table 11. - Paper required for napkins

Year	Paper consumed	Year	Napkin paper produced
	1,000 tons		1,000 tons
1929	28	1940	73
1935	46	1941	86
1937	64	1942	78
1939	64	1943	76
Average (1935, 1937, 1939)	58		

Compiled from Bureau of the Census statistics. Paper consumed partly estimated.

Paper napkins have displaced fabric napkins to a very considerable extent both in public eating places and in the home. This trend has been going on for several years, however, and it is likely that most of the potential market already has been taken. Considering this and considering that the quantity of cotton involved is small, the importance of any further displacement of cotton in this field may be discounted.

Cotton competes with paper in other diverse products such as wrapping twine, window shades, plastics, blankets, cargo and bomb parachutes, bandages, diapers, automobile seat covers, and many other uses. In some of these products such as wrapping twine (paper competes both as twine and as gummed tape), paper's position has been well established as a result of years of competition, and it is likely that further displacement of cotton will be small. In other products such as parachutes, blankets, and bandages, use of paper is relatively new, and competitive possibilities remain to be seen. Future competition between cotton and paper, as in the past, can be expected to be in those applications where a low price for the paper product is sufficient to outweigh the technological advantages, generally but not always possessed by the cotton product.

DEMAND FOR COTTON AS INFLUENCED BY COMPETITION OF JUTE

Jute is a soft, long, multicellular fiber obtained from the bast or inner bark of two closely related plants, round-pod jute and long-pod jute, grown almost exclusively in Bengal and adjoining provinces of India. World production of jute totals about 3,400 million pounds annually (1935-39 average) of which an average of 795 million pounds, or nearly 25 percent, was imported into the United States as raw fiber and manufactured products during the 5 years (1935-39) immediately preceding World War II. Although all jute used in this country is imported, it normally is used in larger quantities than any other fiber except cotton. Imports of jute declined to a minimum of 451 million pounds in 1942, following the entrance of the United States into the war, but were somewhat larger in 1943, although still below the pre-war average (table 12).

Only about 20 percent of the jute imported into the United States is in unmanufactured form. The imported raw jute is converted domestically into such products as bagging for cotton bales, cordage and twine, webbing for upholstery purposes, yarns for wire and cable insulation, fabric for backing carpets and rugs, and various other uses. Another two-thirds of the jute imports consists of burlap, a plain-woven jute fabric, weighing from 6 to 16 ounces per yard, of 40-inch width. Roughly three-fourths of the burlap imported is cut up and sewn into bags, while most of the remainder is used as a wrapping material for covering bales of textile piece goods, meat, and other products. Other important jute imports include bags, chiefly for packaging Hawaiian and Puerto Rican raw sugar and domestic wheat, and bagging for covering cotton bales.

Although there had been little permanent displacement of cotton by jute during the decade or so preceding World War II, cotton can be used interchangeably with jute for the great majority of products generally made of jute. This fact has been illustrated since the entrance of the United States into the present war, for cotton has replaced jute in many uses for which sufficient jute was not available. Whether cotton will retain these additional markets or will be displaced by jute upon the return of peace, is a question of obvious importance in connection with post-war prospects for cotton.

Principal peacetime uses of jute, and their importance in terms of cotton, are indicated in table 13. As is shown in the tabulation, four-fifths of all jute is used for packaging purposes as bags, bagging, and wrapping materials. Competitive factors likely to influence the post-war market for cotton in these uses, as well as in certain other uses, are discussed briefly below.

Table 12. - Imports for consumption of jute and jute products into the United States, 1925-43

Year	Raw jute	Burlap	Bags	Bagging	Other products	Total
	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds
1925-29, average	180.8	609.4	39.6	115.7	5.1	950.6
1930-34, average	154.0	429.4	39.6	86.6	3.6	713.2
1935	146.8	472.8	39.8	50.6	6.5	716.5
1936	176.3	557.3	34.5	62.2	7.0	837.3
1937	265.7	657.7	50.9	89.9	12.0	1076.2
1938	102.1	504.3	43.2	78.8	6.1	734.5
1939	80.3	441.4	30.5	48.4	9.3	609.9
1935-39, average	154.2	526.7	39.8	66.0	8.2	794.9
1940	107.9	503.3	39.9	45.7	7.7	704.5
1941	233.8	529.0	30.5	36.4	6.9	836.6
1942	128.2	254.8	39.1	25.6	3.5	451.2
1943	180.2	407.4	29.6	18.3	3.6	639.1

Compiled from foreign commerce statistics of the United States. Data for 1941-43 are confidential.

Table 13. - Estimated annual consumption of jute products in the United States, 1935-39 1/, and raw cotton equivalents 2/

Product	Jute products: Quantity	Jute products: Percent of total	Cotton equivalents
	Million pounds	Percent	1,000 bales
Bags	435	51	650
Bagging	143	16	141
Wrapping materials for textiles, etc., and other miscellaneous uses of burlap	117	13	173
Backing yarns for carpets and rugs	75	9	179
Cordage and twine	33	4	79
Yarns for wires, cables, rope cores, caulking, etc.	23	3	55
Linoleum backing	15	2	18
Carpets, rugs, mats, etc.	6	1	15
Upholstery webbing	6	1	15
Paddings or interlinings	2	3/	5
Total	855	100	1,330

1/ Approximate. Based in part on production of jute products in the United States, as reported in Census of Manufactures, and on imports of jute products, as reported in foreign commerce statistics of the United States.
2/ Assuming that jute products were replaced by new cotton products that would provide best available substitutes. Given in 478-pound net-weight bales.
3/ Less than 0.5 percent.

Effect of Competition of Jute in Bags

As mentioned in the section on competition of paper, use of burlap and other jute fabrics in bags has been considerably restricted because of reduced imports from India since the beginning of World War II. At the same time, the total demand for bags has increased greatly. In order to meet this increased demand, the use of cotton fabrics and paper in bags has been greatly increased. As indicated in table 8 of the section on paper, consumption of cotton fabrics in bags increased 73 percent from 1940 to 1943 and consumption of paper increased 54 percent, while consumption of burlap declined 33 percent during this period.

Use of burlap in bags was placed under Government control immediately following entrance of the United States into the war, and later its use was prohibited except for bags for certain specified agricultural products, chemicals (other than fertilizer), and other materials. The effect of these changes is indicated by the data presented in table 14, showing the relative use of cotton fabrics and burlap in bags for various purposes during 1941 and 1943. Because of increased total requirements and the use of cotton fabrics to replace burlap, estimated consumption of cotton in bags increased from about 500,000 bales in 1941 to 850,000 bales in 1943.

Total demand for bags can be expected to continue at high levels until sometime after the war, in order to provide packaging for shipments of military supplies and for lend-lease materials, in addition to normal civilian requirements. At the same time, the present unprecedented demand for cotton fabrics can be expected to subside somewhat as shipments from India increase. As concluded in the section on paper, it can be expected that use of cotton in bags during the first post-war year or two will be somewhat in excess of pre-war totals, but will not exceed the total for 1943.

Prior to the war, neither cotton fabrics nor burlap had been displaced, one by the other, to any marked extent for several years, although there had been shifts involving part of the market from time to time with changes in shipping practices, changing price relationships, and other factors. Prices of the particular cotton fabric and burlap constructions used most heavily in bags, for the period of 1931 through 1943, are shown in table 15. Burlap now costs nearly twice as much as during 1935-39 while prices of cotton fabrics have increased by about two-thirds since that period. Cotton bag fabrics at present are priced more favorably as compared with burlap than during the 1935-39 period but not as favorably as during the period of 1939 through 1941.

Table 14. - Estimated consumption of cotton fabrics and burlap in various types of bags, 1941 and 1943

Type of bag	1941			1943		
	Total yardage	Percent		Total yardage	Percent	
		Cotton	Burlap		Cotton	Burlap
	Million yards	Percent	Percent	Million yards	Percent	Percent
Feed and meal	348.0	52.6	47.4	578.1	76.9	23.1
Flour	242.3	90.0	10.0	278.9	97.8	2.2
Sugar 1/	257.3	79.4	20.6	163.0	100.0	-
Potatoes	117.3	6.2	93.8	155.5	30.2	69.8
Rice	29.8	22.8	77.2	23.3	39.9	60.1
Seed	20.8	68.8	31.2	18.9	68.3	31.7
Miscellaneous food and agricultural products	92.1	71.7	28.3	159.1	58.3	41.7
Cement	16.4	100.0	-	5.6	100.0	-
Chemicals	40.8	-	100.0	25.6	41.4	58.6
Fertilizer	72.1	32.0	68.0	55.4	100.0	-
Salt	31.8	52.8	47.2	32.9	100.0	-
Other	195.0	75.5	24.5	319.6	84.2	15.8
Total	1,463.7	57.7	42.3	1,815.9	78.0	22.0

1/ Refined sugar only.
Partially based on estimates from War Production Board and from Textile Bag Manufacturers Association.

Table 15. - Prices per linear yard of typical burlap and cotton fabrics used for bags, 1931-43

Year	Burlap 1/ Price	Burlap 1/ Index 1935-39 = 100	Cotton 2/ Price	Cotton 2/ Index 1935-39 = 100	Difference in favor of burlap
	Cents	Percent	Cents	Percent	Cents
1931	4.98	91	4.78	71	- 0.20
1932	4.23	77	3.96	59	- .27
1933	5.28	96	6.25	93	.97
1934	5.94	108	7.95	119	2.01
1935	5.73	104	7.82	117	2.09
1936	5.12	93	7.12	106	2.00
1937	5.20	95	7.80	116	2.60
1938	4.70	85	5.19	77	.49
1939	6.76	123	5.58	83	- 1.18
1935-39 average	5.50	100	6.70	100	1.20
1940	7.48	136	5.86	87	- 1.62
1941	11.24	204	9.17	137	- 2.07
1942	10.60	193	10.95	163	.35
1943	10.72	195	11.07	165	.35

1/ Averages of mid-month spot prices, New York, given in Daily Mill Stock Reporter for 40-inch, 10-ounce burlap.

2/ Averages of daily prices, f.o.b. mills, given in Journal of Commerce for 40-inch, 3.75, 48 x 44 sheeting.

Prices given above do not indicate the comparison in cost between cotton and burlap bags for any given use but are shown to indicate general trends in prices over the period shown.

As a result of the war, it has been necessary to use cotton bags for many specific purposes for which burlap has undoubted superiority, considering relative costs. It can be expected that burlap will regain its place and that cotton will decline in importance in these uses after the war. For some uses, however, cotton has been shown during the present war to be as well suited or better suited than burlap, and it can be expected that cotton will retain at least part of its gain in such uses. Much will depend, of course, on relative prices. To summarize, cotton can be expected to retain part but not most of its wartime gains over burlap and other jute fabrics after the war.

Effect of Competition of Jute in Bagging for Covering Cotton Bales

It has been customary for many years to wrap practically all American cotton bales with jute bagging. Most of the jute bagging used is a heavy, coarse covering material made from jute butts (coarse, low-grade fibers from the base of the jute plant) and from garnetted jute waste. In addition, a substantial percentage of the cotton crop is covered with sugar-bag cloth, a closely woven jute fabric obtained from used raw sugar bags.

Efforts have been made from time to time to introduce the use of cotton bagging for covering cotton bales, particularly when cotton has been low in price, but without commercial success. Beginning in 1938, however, some cotton bagging has been used each year under an incentive payment program conducted by the Department of Agriculture. Cotton bagging manufactured under this program, and estimated raw cotton equivalents, are shown in table 16. Not all the cotton bagging manufactured has been used, however, particularly during the last 2 years, and as a result there is at present (April 1944) a stock of approximately 3.7 million patterns of cotton bagging on hand.

This accumulation is, to a considerable extent, attributable to the fact that the Commodity Credit Corporation purchased the bagging from manufacturers for stockpiling purposes in view of the unfavorable shipping situation with respect to jute in the early war years. In the meantime, the shipping situation has improved and the Government has encouraged the importation of jute. Although the cotton bagging has been made available for purchase, very little effort has been made to get it into distributive channels.

Table 16. - Approximate production of cotton bagging, 1938-1944, and raw cotton equivalent

Calendar year	Production 1/	Cotton equivalent 2/
	1,000 patterns	Bales
1938	)	)
1939	)- 566.4 3/	)- 6,161 3/
1940	)	)
1941	966.8	10,517
1942	1,924.6	20,937
1943	2,250.6	24,483

1/ Under Department of Agriculture incentive payment.
2/ In 478-pound net-weight bales.
3/ 3-year average.

It is estimated that 5 percent of all bagging used to cover cotton bales during the season 1940-41 was cotton, 2.9 percent in 1941-42, and 5.5 percent during the 1942-43 season.

Cotton bagging manufactured under the incentive payment program of the Department of Agriculture, weighs only 4.5 pounds per pattern as compared with 12 pounds per pattern for jute bagging, but despite its lighter weight has proved to be entirely suitable for the purpose. Among the advantages arising from use of this type of bale covering are savings in transportation costs because of the lighter weight, and the elimination of the manufacturing problems associated with the contamination of the raw cotton with jute fibers. Probably the principal disadvantage, other than cost, has been the bale-weight loss sustained by cotton growers under the prevailing system of gross-weight trading in raw cotton. In 1942, however, all cotton manufacturing and trade organizations modified their trading rules to compensate for this difference.

Prices of cotton and jute bagging are compared in table 17. As is indicated, the sale price, f.o.b. mill, for cotton bagging under the incentive payment program has compared favorably with the opening price on a delivered basis for jute bagging during each year. In all years but 1938, however, the sales price plus the incentive payment has been considerably higher than the opening price for jute bagging. Furthermore, some grades of jute bagging sell for less than the prices reported in the accompanying table. Manufacturers of cotton bagging have been required to meet standard specifications. This has not been true in the case of other types of bagging.

Table 17. - Price per pattern of cotton and jute bagging, and incentive payment per pattern of cotton bagging, 1938-44

Year	Cotton bagging			New 2-pound jute 3/
	Sales price 1/	Incentive payment 2/	Sales price plus incentive payment	
	Dollars	Dollars	Dollars	Dollars
1938	0.45	0.28	0.73	0.72
1939	.45	.28	.73	.62
1940	.76	.25	1.01	.73
1941	.95	4/	1.19	.83
1942	1.00	.35	1.35	1.08 5/
1943	1.05	.40	1.45	1.08 5/

1/ F.o.b. mill.
2/ Payment to mill per pattern of authorized bagging manufactured.
3/ Opening quotation. Delivered price.
4/ The rate of incentive payments was changed several times during the year. The various rates and the number of patterns of bagging manufactured under each were as follows:

15 cents for 521,260 patterns
25 cents for 14,600 patterns
35 cents for 422,601 patterns

5/ Delivered price reported to O.P.A. for rewoven jute bagging.

Manufacturers of cotton bagging are of the opinion that with processing facilities especially designed for the purpose which would reduce the processes to a minimum, cotton bagging could be manufactured and sold at prices competitive with jute bagging. The cost of cotton bagging could, perhaps, also be reduced by mixing with other fibers or with cotton mill waste.

Experience to date under the incentive payment program, indicates that the problem of getting cotton bagging into use is not entirely one of price. Manufacturers and distributors of jute bagging are so well entrenched by means of credits and other arrangements extended to dealers and ginners that it is very difficult to get cotton bagging into distributive channels.

Present indications are that in order to place cotton bagging on a competitive basis with jute bagging, it would be necessary to make provision for:

1. The establishment of processing facilities especially designed for manufacturing cotton bagging at the lowest possible cost.

2. The establishment of marketing facilities for the effective merchandising of the bagging all the way through distributive channels to the ginner.

3. Insuring that weight adjustments for the lighter weight of the cotton bagging apply to farmers' sales in all instances. Presumably this could be done most effectively by the adoption of net-weight trading.

Other Wrapping Materials

In addition to bags and bale coverings for cotton, considerable quantities of jute are normally used in the form of burlap for wrapping bales of textile piece goods, and to a much lesser extent for wrapping other products. Use of burlap for this purpose has been prohibited since the entrance of the United States into the war, and it has been necessary to use cotton goods and paper in its place. Cotton goods thus used, however, have consisted to a considerable extent of mill ends and seconds but it is likely that consumption of cotton for this purpose may have increased by as much as 50,000 bales.

Textile fabrics generally are considered superior to kraft paper, corrugated pasteboard, and other paper products that have been used as a baling material for covering textile fabrics since the beginning of the war. Although cotton fabrics are available that are considered entirely satisfactory for this purpose, they usually have been available in the past only at a higher price than suitable burlap constructions. Assuming that this price relationship continues to hold true in the future, as it probably will, it can be expected that burlap will regain most of its former importance in this field as soon as supplies are again freely available. It is likely, however, that cotton and paper will continue to be used for some purposes where they have been found to be particularly well adapted to users' requirements.

DEMAND FOR AMERICAN COTTON AS INFLUENCED BY COMPETITION OF OTHER GROWTHS

For many years, the difference between total consumption of cotton by the textile industries outside of the United States and the production of cotton in other countries averaged about 6 or 7 million bales annually (table 18). The deficit was supplied by cotton growers of the United States. Our export trade in raw cotton was the principal item responsible for our so-called "favorable balance of trade."

Beginning almost immediately after World War I, some of the principal European countries set out to develop sources of supply of raw cotton within their own colonial possessions. Also they gave encouragement in various ways to the expansion of cotton production in those countries having suitable conditions for such production, particularly where complementary trade arrangements were especially advantageous. These developments reflected a recognition of the strategical importance of cotton not only as a war material but also as an otherwise essential item in view of the definite trend of that period toward national self-sufficiency.

Domestic policies of the United States during the past decade also have had a tendency to encourage the expansion of cotton in other countries. This is particularly true with respect to policies of production control and price support. There has been some offset to this tendency, however, through export subsidies and other measures designed to encourage exports of American cotton.

The net result has been a gradual narrowing of the margin between world production and world requirements for cotton outside of the United States until now the deficit to be supplied by this country has been reduced very materially.

A comparison of the level of prices of those growths of cotton directly or indirectly competitive with American cotton indicates that other growths are being produced and marketed at substantially lower costs than those prevailing in this country. Brazilian cotton, for example, which is reported to be somewhat similar in quality to the bulk of the American crop of upland cotton, now normally sells in Brazilian port markets at approximately 7 cents per pound below American cotton in port markets in this country (table 19).

With ample supplies of other growths of cotton now available at prices substantially lower than those prevailing in this country, prospects for exporting the customary volume of American cotton are not bright. Obviously if American cotton is to retain its export outlets, it must be made attractive to the textile industries of other countries from the standpoint of price as well as quality.

Table 18. - Production and consumption of cotton in other countries and comparison of deficit with exports of American cotton, 1915-40

5-year average	Total foreign			U. S. exports
	Production	Consumption	Deficit	
	1,000 bales	1,000 bales	1,000 bales	1,000 bales
1915-19	7,699	13,134	5,435	5,524
1920-24	8,205	14,319	6,114	6,083
1925-29	10,700	18,453	7,753	8,247
1930-34	11,685	18,745	7,060	7,236
1935-39	16,817	21,609	4,792	5,303
1940	16,352	16,820	468	1,112

Source: U. S. D. A. Yearbooks.

Table 19. - Comparative prices of American and specified foreign growths of cotton, 1923-43

Year beginning August 1	Annual average prices of		
	American Middling 15/16 inch at New Orleans 1/	Brazilian type 5 at Sao Paulo 2/	Indian Oomra, No. 1 fine at Liverpool 3/
	Cents per pound	Cents per pound	Cents per pound
1923	30.83	31.57 4/	24.37
1924	24.87	24.60	23.49
1925	20.51	18.00	18.15
1926	15.37	15.31	14.58
1927	20.32	21.48	18.66
1928	19.25	20.29	16.30
1929	16.59	15.52 5/	12.95
1930	10.50	10.03	8.19
1931	6.40	8.99	6.79
1932	7.41	14.31 5/	7.29
1933	11.12	11.48	9.35
1934	12.79	13.84	10.78
1935	12.05	12.17	10.78
1936	13.45	12.95	10.87
1937	9.24	9.26	7.96
1938	9.04	8.42	7.14
1939	10.23	9.04	9.94
1940	11.06	9.61	11.01
1941	18.17	8.42	13.00
1942	19.96	11.08	11.35
1943	20.35 4/	13.18 5/	-

1/ U. S. D. A. Yearbooks.
2/ Bureau of Agricultural Economics. The Cotton Situation. May 1944. Table 4, page 11.
3/ U. S. D. A. Yearbooks.
4/ Average of 11 months.
5/ Average of 10 months.

PROBABLE DEMAND FOR COTTON FOR SPECIFIC USES

Cotton has always been considered the most versatile of the fibers and its individual uses are numerous. During the pre-war year 1939 approximately 2,700,000 bales of cotton were required in what is known as the apparel uses, 1,800,000 bales in household uses and 2,700,000 in industrial uses. The quantities normally required for individual uses vary from a few bales to about 600,000 bales, the latter quantity representing that normally used in automobile tires.

Perhaps a better conception of the post-war outlook for cotton can be obtained from an analysis of the situation with respect to cotton utilization for a few of the more important specific items or groups of items. For this purpose, these will be grouped into two categories:

1. Those for which cotton's present position is threatened.

2. Those showing promise of providing new or expanded markets for cotton.

Items for Which Cotton's Present Position Is Threatened

In the first group, tire cord perhaps has the greatest public interest at present because of recent developments in the use of synthetic fibers in this field.

For many years the most important single use of cotton has been in tire fabrics. Consumption of cotton for this use reached a peak of about 3/4 of a million bales in 1941. Normally, tire cord comprises about 8 percent of the total cotton consumption in the United States (table 20). The economic importance to American agriculture of this single use can be seen from the fact that it usually takes all the cotton produced on approximately 1-1/2 million acres. Cotton used in tire cord in 1942 had a market value of approximately $60,000,000.00.

Except for experimental use of other fibers, cotton was the only fiber used in the manufacture of tire fabrics until 1937. Although experimental rayon tire fabrics were made as early as 1924, rayon tires were not placed on the market until 1937, following the development for this purpose of high-tenacity rayon and also of a means of making rubber adhere to rayon. High-tenacity rayon for tires is a special type of viscose process

rayon having a tensile strength approximately 70 percent greater than ordinary viscose rayon. It differs from ordinary rayon in being made from cotton linters and highly purified grades of wood pulp instead of from the grades of wood pulp generally used in the viscose process. During its manufacture, a special "stretch-spinning" process is used which orients the cellulose micelles forming the rayon in a direction more parallel to the fiber axis than in ordinary rayon. This results in increased strength.

Table 20. - Estimated raw cotton equivalent of tire fabrics consumed and total consumption of cotton, United States, 1935-43

Calendar year	Total domestic consumption	Raw cotton equivalents of cotton fabric consumed	
	Thousand bales 1/	Thousand bales 2/	Percentage of total
1935	5,767	508	8.8
1936	7,251	599	8.3
1937	7,693	633	8.2
1938	6,062	486	8.0
1939	7,581	701	9.2
Average 1935-39	6,871	585	8.5
1940	8,225	694	8.4
1941	10,832	758	7.0
1942	11,233	543	4.9
1943 3/	10,665	589	5.5

1/ Consumption as reported by the Bureau of Census converted to 500-pound equivalent bales.

2/ Estimated (500-pound equivalent bales) from tire fabric data published in monthly issues of Survey of Current Business and from information furnished by the tire industry (1937-43). Data for 1941-43 average production figures. See table 2.

3/ Preliminary estimate.

The use of rayon for tires increased rapidly from its introduction, but the quantities involved were relatively unimportant until the beginning of the war (table 21). Prior to the war, practically all of the rayon fabric used for tires went into high-speed, heavy-duty truck and bus tires where its reported advantages over existing types of cotton fabrics in durability under heavy service conditions were considered to outweigh its higher price. Some was used also in the larger-size airplane tires.

With the coming of the war, the expansion of rayon in the tire fabric field was given a tremendous impetus by the decision of the military authorities to use high-tenacity rayon in tires for certain classes of military vehicles and aircraft. There has been considerable controversy regarding this decision and the factors leading to it. The decision is said to have been based on the belief that rayon tires would give superior service under the conditions for which they were to be used and that less rubber would be required in making them. These advantages are reported to be attributable to the fact that rayon fabric is lighter and stronger than cotton fabric and that it maintains its strength better under high temperatures. The latter is held to be important because unusually high temperatures are generated by flexing in tires for military vehicles because of their extreme thickness and in airplane tires under the shock of high-speed landing.

Strength at high temperatures was held to be of particular importance if synthetic rubber were used, since synthetic rubber generates more heat than natural rubber. By using rayon cord, it was believed that thinner carcasses could be specified without loss of strength and that the amount of heat generated would thus be reduced. In addition, it was held that a saving in rubber would result.

Subsequent to the decision to use rayon as much as possible in tires for military vehicles and aircraft, the War Production Board began a program to provide high-tenacity rayon in large quantities. In the summer of 1942, there was a capacity for producing about 43 million pounds of high-tenacity rayon annually. This capacity was expanded under successive directives of the War Production Board until provision had been made by the end of 1943 for about 240 million pounds per year. It is not expected, however, that this goal will be reached before 1945. Actual production for 1944 is expected to total about 144 million pounds. Such a quantity, however, is the equivalent of approximately 450,000 bales of cotton. If and when full production is attained, that production would be equivalent to approximately 3/4 million bales of cotton. This represents somewhat more cotton than was used for this purpose immediately preceding the outbreak of the present war.

Table 21. - Quantities of cotton and rayon fabrics used in the manufacture of tires, United States, 1935-43 1/

Year	Cotton fabric		Rayon fabric		Total	
	Thousand pounds	Percent	Thousand pounds	Percent	Thousand pounds	Percent
1935 . . .	208,829	100.0	-	-	208,829	100.0
1936 . . .	246,355	100.0	2/	-	246,355	100.0
1937 . . .	260,194	99.3	1,888	0.7	262,082	100.0
1938 . . .	199,949	98.6	2,876	1.4	202,825	100.0
1939 . . .	288,267	97.7	6,732	2.3	294,999	100.0
1940 . . .	3/	-	3/	-	295,253	100.0
1941 . . .	311,796	92.8	24,105	7.2	335,901	100.0
1942 . . .	233,120	87.5	32,000	12.5	255,120	100.0
1943 4/ .	242,168	84.4	44,857	15.6	287,025	100.0

1/ Data for 1935-36 and 1940 are from Survey of Current Business. Data for 1937-39 and 1941-43 are based on information received from manufacturers of tires and tire fabrics. Rayon fabric totals for 1937-39 are industry estimates. Figures for 1942-43 are production totals but it is believed that they closely approximate quantities of tire fabric used. They include some tire cord used in fuel cells, etc.
2/ A small quantity of rayon fabric was used during 1936.
3/ Data not available.
4/ Preliminary estimate.

In order to obtain high-tenacity rayon in the quantities needed, rayon manufacturers increased their capacity by converting already existing facilities and also by the addition of some new facilities. A substantial part of the cost of these facilities is being supplied by the Defense Plants Corporation. Facilities built by this corporation are rented to rayon manufacturers. Most of the expansion of rayon facilities, however, has been made by the industry itself on the basis of certificates of war necessity which will enable the new facilities to be amortized for tax purposes over a period of 5 years or the duration of the war, whichever is shorter. This is particularly significant from the standpoint of competition with cotton in the post-war period because of the effect it is likely to have on competitive prices.

Despite the rapid increases in the production of high-tenacity rayon, supplies have not been adequate for more than a minor part of the military tire requirements, and cotton fabric has been used to date for this purpose on a far larger scale than rayon. The two most important sizes of military tires -- 7.50 x 20 and 9.00 x 16, which together represent approximately 70 percent of all military tires being made -- are at present being made from cotton.

Available information with respect to the comparative performance of cotton and rayon tires is very meager. The general concensus of the tire manufacturers appears to be that for low-pressure passenger car tires, cotton not only has an advantage in price at present but is just as satisfactory as rayon from the technological standpoint. On the other hand, these manufacturers are of the opinion that rayon is superior to present commercial cotton cord for those types of truck and bus tires which are run with heavy loadings at sustained high speeds.

In evaluating the relative merits of cotton and rayon for tire cord, it will perhaps be well at this point to review briefly the history of the use of cotton for this purpose and to indicate the relationship of that development to the present situation.

When cotton cord fabric was first developed, it was made from sea-island, American-Egyptian, or imported Egyptian cottons. Combed yarns were used in order to obtain maximum strength.

In the meantime improvements were made in cord fabric construction and in the structural features of tires, which developments concurrently with the construction of improved highways made cord strength a less important factor for most types of tires. It was found that when operating on smooth-paved highways, the fabric carcass was far superior to the other parts of the tire. The experience of tire manufacturers in connection with their contracts with large fleet users of tires, under which the manufacturers sold tire mileage, showed that the tire carcass had sufficient

durability on modern highways to justify retreading several times, except in those somewhat unusual cases of breaks from impact of the tires with stones or similar objects. In other words, the conditions which had dictated high cord strength to withstand bruises from impact on rough roads no longer prevailed with the provision of good highways almost everywhere.

Under these conditions and stimulated by price competition between tire manufacturers, shorter and cheaper cotton was used for passenger car tires until during recent years cotton with a staple length in the neighborhood of 1 inch customarily has been used. Obviously, the tensile strength of the cord has been reduced materially but tires have been provided at relatively low prices. These tires have been satisfactory under the circumstances for which they were designed and for which they have been used under normal conditions.

Tires for military use necessarily must meet an entirely different set of conditions. Information is not available as to whether the cotton cord used in the early army tests was especially designed to meet those special requirements. It is an open question, therefore, whether rayon actually would have the reputed advantages over cotton, if suitable types of cotton were selected for each specific use.

In seeking to evaluate the relative merits of cotton fabric for tires, it is logical to compare the physical properties of the two materials. The exact relationships and importance of the various fabric properties to tire performance are not very definitely established, but among the properties that are considered to be important are tensile strength, elongation and elasticity, fatigue life, adhesion, and the uniformity of these properties within the fabric.

Tensile strengths of cotton and rayon tire cords are not directly comparable since rayon cords generally are finer in gage. Comparison is further complicated by the fact that the relationship in tensile strength between cotton and rayon is different in tires than for most uses since tire cord in use has a very low moisture content and is frequently subjected to relatively high temperatures. Cotton loses in strength on drying while rayon gains. Adjusting for differences in weight, rayon has a margin of superiority over present types of cotton cord on a "bone-dry" basis. Once both are in a "bone-dry" condition, they lose strength when heated at approximately the same percentage rate.

Elongation and elasticity of tire cords, like some other properties, are determined partly by basic fiber characteristics and partly by the way the fibers are combined into cords. These properties are of particular importance in determining whether a tire will "grow" in service and whether the tire fabric will rupture instead of "give" if the tire hits an obstacle. In general, rayon tire cords elongate to the

same extent or slightly less than do cotton cords under moderate tensions, but under tensions approaching the breaking load, rayon has a greater elongation than cotton. There is little difference in elasticity or recovery from elongation between the two. Nylon tire cord elongates to a greater extent and has higher elasticity than either cotton or rayon cords.

Resistance of tire cord to fatigue from repeated stresses is highly important, but it is difficult to measure the relative value of various tire fabrics in this regard, and available information is not adequate for direct comparisons. It has been claimed that rayon cords show fatigue values several times that of cotton and that this advantage is accentuated at higher temperatures (L. A. Yerkes in India Rubber World, December 1, 1939). More recent information indicates that rayon has not clear-cut advantage over cotton in this respect, and that under certain temperatures and stress conditions, cotton is superior. The factor of uniformity is highly important in connection with all the properties discussed in the foregoing paragraphs, because deficient individual cords may cause premature tire failure. Rayon tire cord is more uniform than the average commercial cotton tire cord, although it is not so uniform as frequently claimed.

In summary, it can be said that rayon tire cord fabrics have a margin of superiority in technological properties over existing types of cotton tire cord fabrics, but this margin is not so great as has been claimed. Whether the present margin of advantage will be maintained is problematical and depends in part upon relative rates of progress in improving the properties of the two types of fabrics.

In the final analysis comparative prices are likely to determine which material will be used in the post-war period, at least for passenger car tires. Prices of cotton tire cord fabrics are variously quoted at present at from 40 to 54 cents per pound, depending upon the staple length of cotton used and the construction of fabric. In comparison; rayon tire fabric is quoted at 53 cents per pound by one of the rayon manufacturers who converts his product into finished tire cord fabric and at 73 cents per pound by a tire fabric manufacturer who twists and weaves rayon yarn purchased from rayon producers. It should be noted, however, that most tires are made at present from tire fabrics produced by the major tire manufacturers in their own mills. Nonprofit costs to such concerns are reported to show a greater margin in favor of cotton than is indicated by the minimum quotations just given.

Prices of cotton fabrics at present are at the highest levels of recent years as a result of (1) peak cotton prices and (2) abnormally wide manufacturing margins. As is indicated in table 22, prices since 1935 of a typical construction of cotton tire fabric (25/5/3) have

Table 22. - Price per pound of cotton tire fabric as compared with price per pound of raw cotton

Year	Tire fabric 1/ (1)	Cotton 2/ (2)	Difference (1-2)	Raw cotton as percent of tire fabric (2-1)
	Cents	Cents	Cents	Percent
1935	34.8	12.1	22.7	35
1936	30.5	12.4	18.1	41
1937	33.2	11.8	21.4	36
1938	28.1	8.9	19.2	32
1939	28.2	9.3	18.9	33
1940	30.6	10.2	20.4	33
1941	38.2	13.9	24.3	36
1942	43.5	19.6	23.9	45
1943	43.5	20.6	22.9	47

1/ Price at mill of carded peeler cord, 23/5/3 construction. Bureau of Labor Statistics (to May 1942) and Rubber Age (June 1942 through 1943).
2/ 10-market average of Middling, 15/16-inch cotton. Actually, cotton used in tire fabric averages about Middling, 1-1/32 and 1-1/16 inch in grade and staple, and is slightly higher in price.

ranged from as low as 28 cents per pound (1938) to as high as 43.5 cents per pound (1942-43). These prices were from 18 to 24 cents higher than the corresponding average prices of Middling 15/16-inch cotton (10-market average). Actually, the difference would have been slightly smaller, since cotton used in tire fabric averages about 1-1/32 to 1-1/16 inch in staple and consequently costs up to as much as 2 cents more per pound than 15/16-inch staple. The difference is also smaller if a coarser yarn count is used in the tire fabric. For instance, cotton fabrics having a cord construction of 15/4/2 are currently quoted at 2 cents a pound less than the price of the 23/5/3 fabric. 1/

1/ 23/5/3 indicates that the fabric is made up of tire cords composed of 3 strands cabled together, each consisting of 5 number 23s yarn twisted together. Twenty-three x 840 yards of number 23s yarn weigh 1 pound. Similarly with 15/4/2 cotton tire fabric.

Rayon tire fabric generally consists of cords comprised of two strands twisted together of 1,100 denier 2/, high-tenacity, continuous filament, viscose rayon yarn. This type of rayon yarn is now made by five manufacturers. It currently sells at 43 cents per pound, as compared with prices of 47 cents to $1.10 and higher per pound for the "regular-tenacity" rayon used in clothing. It might be explained parenthetically that although the rayon used in tire cord is basically much stronger than the rayon used in clothing, the yarns are not so fine and the costs per pound of winding and packaging are consequently not so great.

To manufacture rayon tire fabrics from the rayon yarn, it is necessary to apply additional twist to the single yarn, ply this into cords, and weave the cords into fabrics. Cost involved is reported to approximate 7 cents per pound in the textile mills of the large tire companies. At least one of the large rayon manufacturers sells finished rayon tire fabrics at a price of 53 cents per pound, or at 10 cents per pound more than the base price for high-tenacity rayon yarn. On the other hand, independent tire fabric manufacturers are reported to be charging as much as 30 cents per pound for converting the rayon yarn into tire fabric.

Prices per pound of cotton and rayon tire cord fabrics, however, do not accurately indicate the comparative costs of using these fabrics in tires since a smaller poundage of rayon than of cotton is required per tire in current practice. Another difference is that it is necessary to specially treat rayon tire fabrics to obtain the desired degree of adhesion between the rubber and the fabric. Although treatments of this sort are sometimes given to cotton fabrics, most cotton fabrics are not thus treated at present. Whether these differences between cotton and rayon will persist is problematical and depend upon technical considerations. At any rate, rayon fabrics used at present average about 25 percent lighter than the comparable cotton fabrics, and it thus is necessary to use only about .75 pounds of rayon fabric to replace 1.00 pounds of cotton fabric. Cost of treating rayon fabrics to improve adhesive properties is estimated at about 8 cents per pound, which represents an additional cost for most tire companies if rayon is used instead of cotton.

Taking these factors into consideration, the cost per tire of using rayon instead of cotton, on the basis of minimum open market prices, is given in table 23, for three different tire sizes. As is indicated, the cost advantage of using cotton instead of rayon ranges from 21 cents per tire for the heavily used 6.00 x 16 passenger car size to $1.44 per tire for the large 10.00 x 20 tire size. The advantage is probably somewhat

2/ Denier is the weight in grams of 9,000 meters of yarn. Converted to English equivalents, 4,059 yards of 1,100 denier yarn weigh 1 pound.

greater if the comparison is made on the basis of nonprofit costs to major tire manufacturers of fabrics made in their own mills, but accurate data on this point are not available. The difference is still greater in favor of cotton if the comparison is made on the basis of 30 cents per pound as the cost of having rayon yarn twisted and woven into rayon tire fabric.

Another factor entering into the cost comparison between rayon and cotton in tires arises from the fact that rayon tire fabric generally consists of a greater number of finer gage cords per inch than does cotton tire fabric, and slightly less rubber is required per tire if it is used. For instance, it is reported by one tire manufacturer, that a 7.50 x 20 (8-ply) tire requires about 6 percent less rubber if made of rayon fabric (.024-inch gage) than if made of .031-inch gage cotton fabric. This advantage does not hold if the cotton cord fabric is of the same gage as the rayon fabric.

Table 23. - Approximate cost per tire of using cotton and rayon fabrics in three specified sizes of tires, 1944 1/

Tire description		Cotton fabric			Rayon fabric			Difference,
Size	Ply	Pounds per tire	Price per pound	Cost per tire	Pounds per tire	Price per pound 2/	Cost per tire	rayon over cotton
		Pounds	Cents	Dollars	Pounds	Cents	Dollars	Dollars
6.00 x 16	4	3.6	40	1.44	2.7	61	1.65	.21
7.50 x 20	8	11.4	40	4.56	8.6	61	5.25	.69
10.00 x 20	12	24.6	40	9.84	18.5	61	11.28	1.44

1/ Based on data furnished by the tire industry and by a rayon producer. Prices are minimum open-market quotations as of January 1944.

2/ Includes cost of treating to improve adhesive qualities, estimated at 8 cents per pound.

To summarize, fabric costs per tire are less if cotton is used instead of rayon, even at today's peak prices for cotton cord. The difference in cost between cotton and rayon, however, varies widely with size of tire, fabric specifications, and depending on whether the fabric is woven and treated in the tire manufacturers own plant. Cost comparisons presented here should, therefore, be considered as only approximate. In addition to fabric cost factors, slightly less rubber is needed per tire if the rayon cord fabric is finer in gage than the cotton tire cord fabric, as is generally true at the present time.

The possibilities for reductions in price of rayon should not be overlooked, particularly in view of the fact that, as mentioned previously, most of the expansion in the production of high-tenacity rayon has been carried out under wartime tax amortization provisions with the result that fixed charges for plant investment should be at a minimum during the post-war period.

In this connection, also, account should be taken of other possibilities for reducing prices of rayon tire cord fabrics. At present, most rayon tire cords are made by plying two 1100 denier rayon yarns, but some 1100 denier 3-ply rayon cords are also used. Consideration is being given to the possibility of using a single 2200 denier yarn instead. This type of rayon yarn would require one less twisting process to convert it into tire cord. Another possibility is that of using rayon staple fiber. High-tenacity staple fiber would probably cost slightly more per pound than ordinary viscose staple fiber, which currently sells for 25 cents. Processing costs, perhaps, would be approximately equal to those involved in making cotton tire cord. The technological and economic feasibility of neither of these possibilities, however, has yet been definitely demonstrated.

As to the present and post-war outlook for cotton in automobile tires, the following conclusions appear to be justified. Some increase in production of tires may be expected during the remaining years of the war, now that increasing quantities of synthetic rubber are becoming available. To meet the demand for tire cord fabrics, it is estimated by Government authorities that a total of about 240 million pounds of cotton tire fabric and about 120 million pounds of rayon tire cord fabric will be produced in 1944. 3/ The resulting total of 360 million pounds of tire cord would be slightly in excess of the record production of 336 million pounds in 1941. Production in 1945, assuming continuation of the war, may be expected to at least equal production in 1944.

3/ Production of high-tenacity rayon is expected to total about 144 million pounds during 1944, but roughly 24 million pounds will be used for fuel cells, hose, etc. In addition, it is expected that 10 million pounds of nylon tire cord fabric will be used for airplane tires, fuel cells, etc.

With the coming of peace, still further increases in tire production may be expected at least during the immediate post-war period. Statisticians in the tire industry estimate that production of tires may total as much as 87 millions per year, about 50 percent more than in 1939, during the first year or so after the war in Europe ends, assuming that restrictions on production of new cars and tires and on use of gasoline are removed. Thereafter, a decline in production to more normal proportions may be expected as the public demand for tires is satiated.

It is then that the factors of competition between rayon and cotton will really come into play. For passenger-car tires, which in the period immediately preceding the war represented about two-thirds of the total tire fabric used, the material to be used will, no doubt, depend largely upon price. For heavy-truck and bus tires, where greater loads and higher temperatures are involved, rayon appears to have a technical margin of superiority over present types of commercial cotton cord. It can be expected, therefore, that rayon will be used for this purpose, except in the event of marked improvement in the quality of cotton tire cord. In that case, price again would be the determining factor. Nylon cord for aircraft appears to have a special advantage from the standpoint of weight as well as of strength.

Possibly an additional important consideration in this connection may be the extent to which synthetic rubber is to be used during the post-war period. This is because synthetic rubber, as now available, generates more heat in tires than natural rubber and for heavy duty work, rayon cord tires run slightly cooler than similar tires made from present types of cotton cord. The important fact in this connection is that unless improvements are made in synthetic rubber and its adaptability for tires, there may be some advantage in returning to the use of natural rubber as a means of improving the competitive position of cotton in the tire cord field.

Another very important consideration in connection with post-war competition between rayon and cotton in the tire cord field has to do with the factor of prestige which rayon has obtained as a result of the widely publicized preference of the military services for rayon. It can be expected that this factor will be exploited in advertising designed to influence consumer purchases.

In order to assure a continuing market for cotton in the tire industry, it is essential that prices of cotton going into tire fabrics be as low as is consistent with the maintenance of adequate incomes for cotton growers. It is also important that all possible steps be taken to improve the quality of cotton tire cord fabrics, both by improving the quality of the cotton available for this use and by improving methods of manufacture.

Items Holding Promise of New or Expanded Markets for Cotton

Cotton Insulation

For a long time, cotton has been known to possess insulating qualities, but its high inflammability has limited its use for this purpose. Recently there have been developed methods of making cotton flame-proof and water-repellant. This development, if fully exploited, is likely to result in a very important new outlet for cotton, particularly for the lower grades and shorter staples, of which we have a burdensome supply.

The insulating industry has now found cotton insulation to be suitable not only for use in homes and other types of buildings, but also for refrigerator cars, trucks, and other uses where insulation against heat, cold, or sound is required.

The processing of cotton for insulation is relatively simple and does not require elaborate or expensive facilities. Cotton lint or cotton waste or a mixture of the two is impregnated with a fire-resistant chemical solution, usually a mixture of borax and boric acid. The impregnation is performed in a simple vat. Impregnated cotton is then passed through a drying oven, where it is thoroughly dried, and from there to a hopper feeder which in turn feeds it into a garnet machine. From the garnet machine flows a batt of uniform thickness. A delivery apron carries the batt to a hot plate where backing with an asphalt coating is applied. Callender rolls press the felted material against the melted asphalt coating causing the backing to adhere firmly. Thus the finished fire-resistant cotton batt fastened to a moisture-resistant backing is ready for use.

Numerous tests show that cotton insulation possesses qualities equal or in some cases superior to other insulating materials. In fact, the "K" factor 4/ for cotton insulation is superior to that of any other material now commercially used for insulation (tables 24, 25, and 26). Furthermore, its weight per cubic foot is only a fraction of that of other material used for this purpose. Cotton insulation weighs only 0.85 of a pound per cubic foot in comparison with competing materials which vary in weight from 1-1/2 pounds to 10 pounds per cubic foot. Cotton insulation

4/ The amount of heat expressed in British thermal units transmitting in 1 hour through 1 square foot of material 1-inch thick for a difference in temperature of 1° F. between the two surfaces of the material.

does not sag or settle, as does insulation made from heavier materials. Its natural cohesiveness makes it cling to the wall and studding surfaces to which it is applied. Its light weight makes it an ideal insulator for such objects as refrigerator cars and trucks and for aircraft where weight is an especially important factor.

Table 24. - Insulating value of various insulations

Material	Description	Weight per cubic foot	Insulating value (or "K" factor) 1/
Cotton	Flame-proofed cotton lint in batt form	0.85	.242
Rock Wool	Fibrous material made from rock -- all forms	10.00	.268
Mineral Wool	Fibrous material made from slag	10.50	.310
Glass Wool	Fibrous material made from glass slag	1.50	.270
Celotex	Rigid insulation made from sugar cane fiber	13.50	.330
Balsam Wool	Chemically treated wood fiber between layers of paper	2.20	.270
Cabots Quilt	Eel grass between Kraft paper	3.4	.25
Redwood Bark Wool	Wood pulp of redwood trees	3.00	.310
Insulite	Fibers from northern woods	15.9	.330
Corkboard	Pure, no binder added	7.0	.270
Sheepwood	Animal fibers	8.5	.338

1/ Insulating value means the amount of heat expressed in British thermal units transmitted in 1 hour through 1 square foot of a homogeneous material 1-inch thick for a difference in temperature of 1° Fahrenheit between the two surfaces of the material. The lower the factor, the better the insulation.

Table 25. - Comparative thickness of commercial insulations required to equal insulation value of 3-5/8-inch cotton insulation

Material	Thickness required
	Inches
Cotton	3.625
Rockwool	3.8
Glasswool	4.0
Corkboard	4.0
Balsam Wool	4.0
Mineral Wool	4.6
Redwood Bark	4.6
Cork (regranulated)	4.6
Cabots Quilt	3.7
Celotex	4.9
Insulite	4.9
Rock Cork	4.9
Sheepwool	5.1

Table 26. - Comparative thickness of building materials that would be required to equal insulation value of 1 inch of cotton insulation

Material	To equal 1-inch thick cotton insulation
	Inches
Sand and gravel concrete	52
Stone	52
Stucco	52
Limestone concrete	46
Slate shingles	41
Composition shingles	27
Brick (low density)	20
Concrete (cinder)	19
Plaster on metal lath	18
Wood shingles	5
Tile (typical hollow clay 4")	4
Yellow pine	4

Computed from data in Heating and Ventilating Engineers Guide (1940), pp. 94, 99.

For use in insulating buildings, cotton insulation has the special advantage of being easy to apply and can be handled without danger of skin irritation which is a problem with many insulating materials. Labor costs for applying insulation to buildings are estimated to be 40 percent less for cotton insulation than for competing materials.

The program for cotton insulation authorized for the present fiscal year will require approximately 140,000 bales of raw cotton. An idea of the potential market for this use may be obtained from the fact that if cotton supplied only 10 percent of the insulating material, a market for from one-half million to three-fourths million bales of cotton would be provided annually.

Under the prosperity conditions likely to prevail during the immediate post-war period, a great expansion is expected in the field of air conditioning and refrigeration. This will afford an enormous market for insulating materials. It is estimated that there are at present about 30 million individual dwelling units in the United States that are not insulated. These units if insulated with cotton in the attic only would require approximately 12-1/2 million bales of cotton. It is expected that about one million new dwelling units will be constructed annually for a number of years after the war. These units will, no doubt, feature air conditioning and insulation. It requires about 200 pounds of cotton to insulate an attic for the average-sized dwelling and about 400 pounds for more complete insulation.

Requirements for insulating a refrigerator car is 350 pounds, a refrigerator truck 150 pounds, and a household refrigerator 7 pounds.

Cold-storage lockers and fresh-freeze units will require increasing amounts of insulating materials during the post-war period. These figures will give an idea of the potential market for cotton in this field. With aggressive exploitation, insulation could develop into our largest single use for cotton.

The principal problem in getting cotton used for insulation is likely to be that of cost. Present estimates are that to meet competition, raw cotton would have to be obtained at approximately 8 cents per pound. Tests have shown that cotton Low Middling and lower in grade with sound staple 13/16 inch and shorter is satisfactory for this use. Present prices for cotton of this type are now substantially above this level (table 27). The further mechanization of cotton production and harvesting in the areas that normally produce short-staple cotton should make it possible to provide such cotton for this use without adversely affecting the incomes of cotton growers.

The extent to which cotton could be used for insulation at present price levels and without a subsidy will depend upon the aggressiveness of the salesmanship of manufacturers and distributors in exploiting the superior advantages of cotton over competing materials.

Table 27. - Cotton prices for selected low grades at Dallas, Tex., together with loan value as of March 15, 1944 1/

Grade	Staple			
	3/4 inch		13/16 inch	
	Spot price 2/	Loan rate	Spot price	Loan rate 3/
White:				
LM	14.58	None	15.08	14.46
SGO	13.58	"	14.08	12.86
GO	12.38	"	12.88	11.91
Spotted:				
SLM	14.28	"	14.78	14.41
LM	13.08	"	13.58	12.61
Tinged:				
M	12.83	"	13.33	14.11
SLM	11.83	"	12.33	12.76
LM	10.93	"	11.43	11.76
Stained:				
M	11.98	"	12.48	12.41
Average	12.83	"	13.33	13.03

1/ Basis Middling 15/16 inch flat in warehouse.
2/ Estimated.
3/ Gross weight.

Plastics

From the standpoint of providing new markets for cotton, plastics is one of the most promising of the new industries that have had an accelerated expansion because of the war. At present, cotton fabrics are being used extensively as filler or reinforcement in the manufacture of those plastics which require relatively high tensile strength, light weight, toughness, flexibility, and moldability. This is particularly true with respect to the laminated plastics.

In addition to the cotton fabrics used in laminated plastics, considerable use is made of cotton linters and cotton rags in the plastics industry. Cotton linters are used in large quantities as a source of cellulose for a number of plastic compounds. Cotton rags are used in the manufacture of special grades of paper for use as fillers in laminated plastics and also in the manufacture of paper for use in making "vulcanized fiber," another type of plastics. In addition, cotton rags and other cotton wastes are cut up into various finenesses for use as fillers for molding compounds. These materials do not contribute to the demand for raw lint cotton, however, and consequently will not be considered further in this section.

About 80 percent of the filler now used for laminated plastics is cotton fabric. It is estimated that in 1943 approximately 50 million pounds of cotton textiles were used in the production of plastic laminates alone. This represents approximately 110 thousand bales of raw cotton. Laminated plastics were estimated to comprise approximately one-fourth of the total plastic production in 1943.

A conception of the extent of use of cotton fabrics in the manufacture of laminated plastics may be obtained from noting the construction of a typical laminated sheet of 1-inch thickness which may consist of as many as 70 layers of 8-ounce duck or of about 150 layers of 4-ounce print cloth impregnated with thermosetting 5/ or thermoplastic 6/ resins.

As a result of the pressure for the production of plastics for war purposes, there has been an extensive conversion of facilities of industrial plants that formerly produced such products as furniture, musical instruments, household equipment, and many other products. Many of these facilities will continue in the production of plastics during the postwar period.

5/ Property of undergoing chemical change when heated to produce a hardened product.

6/ Property of softening under heat even after being molded.

It appears probable that plastics will find extensive use in such fields as the automotive, aircraft, office-equipment, building-construction, and house-furnishing industries, as well as many others. In these and in many other fields, plastics will probably replace wood as well as steel and other metals for a wide field of uses. Among the specific items that manufacturers of plastics have in mind as post-war applications are walls and partitions, shingles, moldings, baseboards, and other items entering building construction as well as venetian shades, refrigerators, pianos, and even bathtubs.

Plastic laminates are reported not only to challenge established uses of various metal, rubber, and wood products but also of leather. One of the largest shoe manufacturers recently purchased 50,000 pairs of shoe soles made of cotton press cloth and thermoplastic resins. This application is cited to illustrate how plastic materials and cotton fabrics can readily complement each other because of a common characteristic of flexibility. When the two are combined in a laminated plastic, there is added to this flexibility strength and toughness that cannot be obtained economically with either material alone.

The present trend in the use of thermoplastic laminates is likely to expand the application of the laminated plastics in such fields as the automotive and aircraft industries because of the greater shock resistance of the thermoplastic types as compared with the thermosetting types. Applications are being considered in the design of closed car types of post-war automobiles and airplane cabins.

From the standpoint of weight-strength ratio, the laminated plastics have advantages over most of the metals. The specific gravity of the general run of aluminum products is approximately 2.60 as compared with about 1.30 for the general run of plastic laminates. Although the tensile strength of the plastic laminates now available is substantially below that of aluminum, possibilities for improvements with respect to this factor are such as to indicate promise of providing such plastics with a weight-strength ratio comparable to that of aluminum -- one of the lightest of the metals. In the case of objects of intricate shape, the molded plastic laminate would cost far less than the aluminum product.

Competing materials as fillers for plastics are paper, fiberglass, jute, and sisal as well as the synthetic fibers. Prior to 1942, paper-filler materials of relatively low cost were used for approximately 75 percent of the total laminated plastic tonnage. High-strength plastics for many war purposes have required manufacturers to change over to cotton fabric fillers. For the low-pressure laminates, the flexibility of cotton fabrics over compound curves give them a pronounced advantage over paper. Furthermore, plastic laminates with paper filler do not have the high impact strength that is provided by cotton. Another disadvantage of paper

is that it tends to char at a lower temperature than that at which cotton carbonizes. Laminates with paper filler also require a longer curing period. Under extreme conditions of service, it has been found that laminated plastics with paper filler have a tendency to delaminate and thus to result in premature failure of the product.

The paper industry, however, has done intensive research in an attempt to retrieve the markets it has lost to cotton. It has succeeded in producing laminating paper of exceptional strength but which as yet is not being used extensively.

Fiber glass for use as plastic filler has the advantages of extremely high tensile strength and excellent insulating qualities. Offsetting these advantages are high cost (7 to 10 times higher than cotton fabrics), low resistance to shearing, and the difficulty of getting a tight bond between layers of fiberglass fabric in the laminates. The best results with fiberglass are now being obtained when the fabric is made of fiberglass yarns in the warp which are held in place by fine cotton threads in a leno-weave construction.

Cotton has distinct advantages over the other fibers such as jute, sisal, and rayon as plastic filler because of lower moisture absorption, which means greater dimensional stability in the finished product.

Cotton fabrics for use as plastic filler are relatively high-priced in relation to paper, sisal, and jute. If, therefore, they are to be used for this purpose, it will be on the basis of the quality of the end product. The position of cotton in this respect can, no doubt, be greatly improved by the designing of special cotton fabrics having characteristics more suitable for this purpose than those now available. To date the standard cotton fabric constructions have been used mostly because they were readily available. Apparently there is need not only for the construction of stronger cotton fabrics but with the strength more nearly in true balance warp-and-filling wise than is now customary in cotton fabric construction. This would obviate the need for reversing the warp and filling directions in alternate layers as is now required in the laminated plastics. Furthermore, the physical and mechanical properties desired for plastics designed for various uses vary widely and will, no doubt, make it necessary to design the fabric filler so as to enhance the quality of the end-use product. Apparently, those properties of raw cotton which for most textile uses are now considered desirable in the improved varieties, will further enhance the competitive position of cotton as applied to the field of plastics.

Another promising application of cotton in the laminated plastic field is in the unspun form. Recently considerable attention has been attracted to the use for this purpose of carded cotton fiber in web form with the fibers longitudinally parallel and held together filling-wise by such devices as a surface imprint of latex or such bonding agents as cellulose acetate applied in the form of a light spray or admixed as fiber with the cotton. Depending primarily upon the success of efforts to facilitate the handling of the cotton web in laying up for laminating, this development in the use of cotton for this purpose offers considerable promise in the production of plastic laminates with a tensile strength far greater than that now obtainable by the use of woven-cotton fabrics as filler. Also, this application would greatly enhance the competitive position of cotton filler because of relatively lower costs.

To summarize, it may be said that the use of cotton as filler for plastics may develop into one of the major uses for this commodity. The technological advantages of cotton over other filler materials not only in the form of woven fabrics but more particularly as unspun fiber, would indicate its use for a wide field of plastic products where quality is important. If cotton is to have an assured place in this field, however, a special effort will have to be made to provide cotton of the quality and in the form most suitable to meet the varying requirements of the plastic industry because other materials will compete for this market.

Special Clothing Fabrics

The development of special military fabrics is likely to have a significant effect upon civilian apparel in the post-war period. This is particularly true with respect to light-weight, wind-resistant, water-repellant cotton fabrics that have been developed by the Quartermaster Corps. Tests made by the Army show that light-weight, tightly-woven cotton fabrics, when treated with a chemical finish, provide warmth without the cumbersome weight of woolen fabrics. It is expected that in the post-war period, when such fabrics are more generally available, they will be used extensively for all types of overclothing and particularly for winter work clothing.

COTTON AS A RAW MATERIAL FOR SYNTHETIC FIBERS

Rapid expansion in rayon production has made necessary the use of increasing quantities of the principal raw material, cellulose, most important sources of which are cotton linters and wood pulp. Technological developments in the manufacture of rayon have had a marked influence on relative quantities of linters and wood pulp used in recent years. It will, therefore, be necessary to review these developments from a raw material viewpoint. The story is somewhat different for each of the three principal processes of making rayon, commonly known as (1) the viscose, (2) the cuprammonium, and (3) the acetate.

Although raw lint cotton was used to some extent as a source of cellulose in manufacturing rayon in the very early stages, it soon gave way to the cheaper materials -- cotton linters and wood pulp. The viscose method of making rayon was developed about 1900. From that time until about 1925, practically all viscose rayon was made from wood pulp. After 1925, varying mixtures of wood pulp and cotton linters were used, but continued improvements in wood pulp for rayon, combined with an advantage in price, caused a shifting away from cotton linters. No linters at all have been used for common grades of viscose rayon during the last few years. Increasing quantities of cotton linters have been used since 1937, however, in the production of high-tenacity rayon by the viscose process for use in tires and more recently in other products.

Linters were used exclusively as the source of cellulose for the other important processes, acetate and cuprammonium, until about 1940. Since then, special highly purified grades of wood pulp have become available and are now being used successfully and on a large scale in these processes.

Table 28 shows consumption of linters in the manufacture of rayon from 1935 through 1943 as compared with consumption in all uses. In 1935, about 227,000 bales of cotton linters were used in rayon. This represented about 30 percent of total consumption for all uses. Some slacking off occurred from 1936 through 1938, primarily due to the fact that viscose manufacturers were switching from linters to wood pulp as their source of cellulose. Although the production of acetate rayon from linters increased during this period, the increase was not enough to offset the amount of linters displaced in the manufacture of viscose rayon. Production of acetate rayon also increased from 1939 through 1941, and this increase was accompanied by a rise in consumption of linters. In 1941, an all-time high of 324,000 bales of linters was consumed in the manufacture of rayon, representing 22 percent of the total consumption in all uses. Consumption of linters in the manufacture of rayon was much smaller in 1942 and comprised only 15 percent of the total linters consumed during this year.

Table 28. - Consumption of cotton linters in the manufacture of rayon and total consumption in all uses, United States, 1935-43

Year	Total consumption 1/	Consumption in rayon: Quantity 2/	Consumption in rayon: Percent of total
	1,000 bales	1,000 bales	Percent
1935	747	227	30
1936	765	209	27
1937	810	196	24
1938	743	167	22
1939	952	220	23
Average 1935-39	803	204	25
1940	1,116	267	24
1941	1,473	324	22
1942	1,441	220	15
1943	1,350 3/	247	18

As given in Weekly Review, American Cotton Linters, June 15, 1943.

1/ From Bureau of the Census. In running bales averaging about 620 pounds gross.

2/ Based on data in Rayon Organon, May 1943. In 600-pound net-weight bales.

3/ Preliminary.

Shifts from linters to wood pulp as source of cellulose for rayon are shown in table 29. As is indicated, 37 percent of the cellulose used for rayon in 1935 was derived from cotton linters as compared with 63 percent from wood pulp. From 1937 through 1941 the proportions remained fixed at 25 and 75 percent, respectively. But in 1942 they changed to 15 percent linters pulp and 85 percent wood pulp. The percentage made of linters was approximately the same in 1942 as in the 4 preceding years. A factor in this shift was the earmarking of a large part of cotton linters supply for nitration purposes. Some increase in consumption of linters in rayon during 1944 over 1943 can be expected because of (1) increased production of high-tenacity viscose rayon, made partly from linters, (2) shortages of wood pulp accompanied by release of some of the restrictions on linters, and (3) a slight increase in production of rayon over the levels of previous years.

Table 29. - Cellulose consumption by the rayon industry in the United States, 1935-43

Year	Total pulp		Wood pulp 1/		Linters pulp 1/	
	1,000 tons	Percent	1,000 tons	Percent	1,000 tons	Percent
1935	137	100	86	63	51	37
1936	151	100	104	69	47	31
1937	176	100	132	75	44	25
1938	147	100	110	75	37	25
1939	194	100	145	75	49	25
Average 1935-39	161	100	115	71	46	29
1940	238	100	178	75	60	25
1941	287	100	214	75	73	25
1942	330	100	280	85	50	15
1943	336	100	281	84	55	16

Source: Rayon Organon.

1/ Wood and linters in purified form as used by rayon producers.

Linters pulp is generally regarded as superior in quality to wood pulp as a source of cellulose for some types of rayon, but as having little or no advantage for others. Since it usually is considerably higher in price than wood pulp, it is used only for those types of rayon for which the desired properties cannot be obtained from wood pulp.

Considerable improvement has been made in the quality of wood pulp and in methods of processing it in recent years, with the result that this material has displaced linters to an increasing extent as a source of cellulose for rayon. No linters are used at present in the viscose process except in the manufacture of high-tenacity rayon and possibly small quantities of other special products. It is reported that some manufacturers can obtain the required strength in high-tenacity rayon only by use of linters, but some are successfully using varying percentages of wood pulp and at least one is using wood pulp entirely. Although there is little question that better high-tenacity yarns can be obtained by using linters instead of wood pulp, the advantage may not be sufficient to assure that linters will continue to be used for this purpose in the future.

As already noted, linters were the sole source of cellulose for rayon made by the acetate and cuprammonium processes before the war. Considerable use is now being made of special highly purified grades of wood pulp, which have been developed and placed on the market during the last few years. Although it is generally agreed that higher-quality acetate and cuprammonium rayon can be made from linters than from wood pulp, there is no question that the wood pulp product is sufficiently satisfactory for ordinary purposes.

Wood pulp has been considerably lower in price than cotton linters pulp throughout the last 9 years (1935-43), and its price has been more stable (table 30). In comparing these prices, it should be noted that standard grades of wood pulp have a usable cellulose content of only about 92 percent while linters have a content of nearly 98 percent. Consequently, linters pulp can be priced slightly higher per ton than wood pulp and yet be the most economical source of cellulose. Despite this consideration, wood pulp is still much less costly than linters pulp. The greater stability of wood pulp prices is also an advantage favoring use of this material since less risk of losses from price changes is involved in using it. Another cost factor involved in comparing the two materials, is the cost of changing over in the manufacturing process from one material to the other. This factor operates in favor of the material already being used.

Table 30. - Approximate prices of rayon grades of cotton linters pulp and wood pulp, United States, 1935-43

Year	Cotton linters pulp 1/	Wood pulp 2/
	Dollars per ton	Dollars per ton
1935	175	70
1936	162	70 - 72.50
1937	175	70 - 72.50
1938	115	85 - 97.50
1939	113	75 - 80
1940	133	75 - 85 3/
1941	152	85 3/
1942	163	85 3/
1943	183	85 3/

Source: Bureau of Agricultural and Industrial Chemistry, Agricultural Research Administration, and Rayon Organon.

1/ F.o.b. plant.

2/ Ex dock, nearest Atlantic or Gulf port.

3/ Special grades for use in making acetate rayon were quoted at $100 per ton from 1940 to July 1943 and at $110 for the remainder of the year.

There are a large number of potential sources of cellulose for rayon besides wood pulp and cotton linters but none are used commercially in the United States at present because of prohibitive costs. The whole cotton plant has sometimes been mentioned as a potential source of cellulose for the rayon industry. Experiments carried out a few years ago by the North Carolina Agricultural Experiment Station, however, cast serious doubt as to the technological and economic feasibility of the use of the entire cotton plant as a source of cellulose for synthetic fiber.

Lint cotton has also been considered as a source of cellulose in the manufacture of rayon. It has a high cellulose content, but certain difficulties are involved in converting it to pulp. Although the impurities in linters are easily removed, those in lint cotton (pieces of boll and stalk, sand, etc.) can be extracted only at greater expense. It is necessary also to cut lint cotton into lengths comparable to linters in order to convert it into pulp on present commercial equipment. Although it has been found that entirely satisfactory pulp can be made from lint cotton, there seems to be little possibility of using lint cotton for this purpose under normal conditions since its price, even at depressed levels, is not competitive with linters or wood pulp.

Further expansion in production of rayon may be expected in the post-war period and there will be an increasing need for cellulose in the industry. It is uncertain whether there will be an increased market for linters, however, as a result of this trend. During the last few years the percentage of rayon made from cotton linters has steadily declined, largely because of continued improvements in the quality of wood pulp and the lower price at which wood pulp is available. This trend has reached the point where the most rayon, by far, is now made from wood pulp and linters are used only for part of the high-tenacity viscose rayon and for part of the rayon made by the acetate and cuprammonium processes.

Production of high-tenacity viscose rayon (for tire cord and other products) is being expanded rapidly at the present time under a program calling for an output at the rate of 240 million pounds annually in 1945. Linters will be used for part of this production but one manufacturer is already reported to be producing this type of rayon entirely from wood pulp. It can be expected that there will be a declining percentage made from linters as manufacturing techniques improve. As for the acetate and cuprammonium processes, only linters pulp was used in these processes before the war, but newly developed, highly purified grades of wood pulp are now being used successfully on a large scale. Whether makers of rayon by these processes return to use of cotton linters, when they again become available for normal civilian uses, will depend on whether they consider the gain in the quality of their product sufficient to offset the higher cost of linters and the cost of changing back their manufacturing processes. The greater stability of wood pulp prices will also operate as a factor favoring use of wood pulp.

In conclusion, it may be stated that since the technological advantage to be gained by use of linters in rayon manufacture is smaller now than ever before, use of linters in this industry will depend to an increasing extent upon the price at which they are available. Prices of chemical grades of linters are governed to a considerable extent by the demand from the rayon and other chemical industries, as they are the principal users. Consequently, it can be expected that prices of the chemical grades will tend to fall to the point where it is economically feasible to use them in rayon and other comparable cellulose products for civilian use. This conclusion will be valid only if there is no abnormal demand for use of linters in munitions and if the price is not supported by Government measures. It can be expected that most rayon will continue to be made from wood pulp, but that linters will continue to find use for certain requirements.

The possibility of using lint cotton as a source of cellulose for rayon and other commercial products may be discounted, since the cost is far too high even when cotton prices are at depressed levels.

POSSIBILITIES FOR IMPROVING COTTON'S COMPETITIVE POSITION

It is apparent from the foregoing that in the post-war period, American cotton is likely to face strenuous competition for markets. It is also quite clear that the extent to which cotton is able to retain its position or to develop new or expanded markets will depend not only upon technological factors of suitability for specific uses but in a large measure, upon the price of cotton in relation to competing materials. Readjustments to enhance cotton's position from the standpoint of physical suitability for specific uses will require the coordinated efforts of cotton breeders, producers, ginners, and marketing agencies as well as processors. Readjustments from the standpoint of the price factor likewise may be necessary on the part of each of the various elements of the cotton industry.

Improvements in Quality

Through Planting Improved Varieties

Fiber and spinning research and testing conducted during recent years have established the relationships that exist between the physical properties of cotton fibers and their performance in processing. Based largely upon the results thus made available, cotton breeders have made remarkable progress in developing improved varieties of cotton which not only provide superior spinning performance but also high yields. These varieties are now being planted on an extensive scale and are having a pronounced effect on certain aspects of quality in the crop. This is particularly noticeable with respect to staple length as is indicated by the data presented in table 31. From an average staple length of about 15/16 inch in 1928 rather consistent progress has been made until the average staple length is now about 1 inch. Since the grade factor of cotton quality is determined largely by weather conditions and by harvesting and ginning practices, the situation with respect to grade will be discussed in a later section.

For many years, cotton manufacturers and marketing agencies have attempted to deal with quality in raw cotton primarily on the basis of grade and staple length. The factors determining grade have provided a fairly reliable index of manufacturing waste as well as the extent of fiber deterioration. Staple length has provided a fairly good index of the use to which a given lot of cotton is adapted, the approximate yarn strength to be expected, and the machinery organization required to process it. It has long been recognized, however, that factors of quality other than grade and staple length are also important from the standpoint of spinning performance. These factors have been rather loosely referred to under the inclusive term "character" and have been somewhat elusive from the standpoint of standardization and objective evaluation in commercial practice.

Table 31. - Average staple length of upland cotton ginned in the United States and percentage of crop 1 inch and longer in staple, crops of 1928-29 to 1943-44

Season	Average staple length (32nd inches)	Percent of crop 1 inch and longer
1928-29	30.36	21.4
1929-30	30.22	22.8
1930-31	30.44	23.0
1931-32	30.86	27.0
1932-33	30.90	26.8
1933-34	31.10	28.6
1934-35	31.16	33.0
1935-36	30.94	30.9
1936-37	31.54	43.0
1937-38	31.10	33.6
1938-39	31.66	51.4
1939-40	31.29	49.3
1940-41	31.92	59.8
1941-42	31.98	62.3
1942-43	31.90	61.3
1943-44 1/	31.50	57.2

1/ Preliminary.
War Food Administration, Office of Distribution, Cotton and Fiber Branch.

The recent development of laboratory methods for the measurement of such physical properties of cotton fibers as tensile strength, fineness, length uniformity, and maturity, together with the establishment of the relationships of these fiber properties to processing performance and to yarn and fabric quality, has done much not only to expedite the development of new varieties and strains having superior fiber properties but also to stimulate an interest on the part of cotton manufacturers and merchants in the more precise consideration of the factors of quality. The fact that various fiber types are inherent characteristics of specific varieties and growths of cotton has now become well established. As manufacturers are becoming acquainted with the fiber characteristics of specific improved varieties and growths and their adaptability to specific uses, they are discovering that character, the "third dimension" of cotton quality, can be dealt with most effectively in terms of variety and growth and that the inclusion of this factor, along with grade and staple length, greatly increases the efficiency with which supplies of raw cotton possessing fiber properties most suitable for specific uses can be procured.

Unfortunately, however, present procedures in the production, ginning, handling, and marketing of cotton do not, for the most part, permit the extensive use of this device for enabling cotton manufacturers to procure their supplies of raw cotton on a satisfactory basis. Although much progress has been made in standardizing the production of a single improved variety on a ginning community basis, the standardized areas in most instances are too small under present procedures of handling cotton to permit effective marketing on an identified variety basis. Thus, although the leading improved varieties now provide a range in quality which, if selected for specific fiber properties most suitable for individual uses, could, with few exceptions, provide textile raw material comparable in performance with any substitute materials now available, it is not feasible under the present marketing system to procure cotton of specific known varieties except in rather isolated instances.

To enable cotton manufacturers to procure, in the quantities required, the varieties or strains of cotton most suitable for a specific use will necessitate the standardization of the production of improved varieties on a sizable area basis and the development of a system for retaining the identity of the cotton by variety and growth throughout marketing channels.

Further improvement in the physical properties of cotton fibers through intensified activities on the part of cotton breeders, together with the more general planting on a standardized area basis of those varieties best adapted to specific areas, will do much to enable cotton to retain or improve its position as a raw material for textiles. Competing cotton breeders are making an intensive effort to produce strains of cottons most suitable for specific uses. They are making extensive use of the Department's fiber and spinning laboratories for testing their cotton, and it can be expected that seed of the improved varieties and strains will be available for planting by cotton growers.

The planting of the improved varieties on a standardized producing-area basis is being given a considerable impetus by the classification service made available free under the provisions of the Smith-Doxey Act, for groups of cotton growers who have organized for cotton-quality improvement. The real need is for larger standardized variety areas.

Harvesting and Ginning Practices

Although consistent improvement has been made in the length and other fiber properties of American cotton, the grade of the crop has shown a steady decline as is indicated by table 32. This trend has important implications from the standpoint of competition with other materials for the reason that the domestic cotton textile industry has for the most part used the better grades of cotton. The lack of availability of such grades would provide an additional inducement for cotton manufacturers to turn to rayon staple fiber

which can be run on a cotton system. As a general rule, American cotton mills are not equipped with dust control facilities which are needed for processing the lower grades. For the most part, American cotton mill operatives object to handling the lower grades.

Care in the harvesting and handling of cotton on the farm and the proper use of conditioning, cleaning, and ginning facilities now available at modern gins would do much to reverse the downward trend in the proportion of the American cotton crop represented in the better grades.

Table 32. - Strict Middling and better (White and Extra White) expressed as a percentage of total production, United States, 1928-29 to 1943-44

Season	Percent
1928-29	47.6
1929-30	35.3
1930-31	40.8
1931-32	42.6
1932-33	28.7
1933-34	29.1
1934-35	47.4
1935-36	27.6
1936-37	25.5
1937-38	17.6
1938-39	22.9
1939-40	18.5
1940-41	12.5
1941-42	7.7
1942-43	7.2
1943-44 1/	15.5

1/ Preliminary.
War Food Administration, Office of Distribution, Cotton and Fiber Branch.

Reduced Costs

Whether American cotton can meet the price competition it is likely to face without seriously affecting incomes of cotton growers will depend primarily upon possibilities for reducing costs. Possibilities should be explored not only for reducing production costs on farms but also for reducing costs of ginning, packaging, handling, and marketing as well as processing.

Mechanization of Production

Considerable attention is now being given to the possibilities of reducing farm production costs by mechanization of various farm cultural practices and harvesting. Interest in these possibilities is being stimulated by recent developments in mechanical harvesting as well as by the present shortage of labor on cotton farms. The discussion of mechanized farm production, however, is beyond the scope of this report and will be taken into account here only to the extent that such developments affect the ginning, marketing, and processing of cotton.

After many years of developmental work on the part of a number of individuals and firms, some of the leading manufacturers of farm machinery now plan to place cotton picking machines on the market.

According to available information, cotton was harvested by machine during the past season at a saving in actual harvesting costs of more than $20.00 per bale. A major part of this saving, however, was offset by increased ginning costs and more particularly by the discounts for the lower grades obtained by machine harvesting. On the average, the net saving from machine harvesting, perhaps, approximated $10.00 per bale at prevailing grade differentials. (Should all cotton be machine-harvested, the supply of lower grades would increase. Hence grade discounts could be expected to widen, thereby further reducing the net saving to the cotton grower.)

A saving of this magnitude in the cotton grower's cost of production is, of course, a very significant item. This is particularly true in view of the fact that the future of American cotton as a textile raw material in the post-war period will, perhaps, depend very largely upon its price in relation to other growths of cotton as well as to synthetic fibers. The mechanical harvester appears to offer one of the most promising possibilities for reducing farm production costs.

With present mechanical harvesting and ginning equipment, however, grades comparable to those obtained with hand picking cannot be obtained. During the major part of the harvesting season, the hand-picked cotton is

approximately two grades higher than machine-picked under otherwise comparable conditions and with present mechanical harvesting and ginning equipment. Late-picked cotton perhaps averages about one-half grade lower when machine-picked.

Any general lowering of the grade of the American cotton crop under conditions now prevailing and likely to prevail in the immediate post-war period would hasten the displacement of cotton by other textile raw materials. Because of labor conditions primarily, cotton manufacturers who customarily use the better grades would in many cases turn to rayon staple fiber if such grades were no longer available.

Thus, although the general adoption of mechanical harvesting would aid cotton growers in meeting price competition, the lower grades that would be obtained with existing facilities would tend to dry up many customary markets for cotton.

Apparently, the successful adaptation of mechanical harvesting to the American cotton crop is contingent upon the development of means for maintaining or improving the quality of the product placed on the market. This problem has been recognized by those who have been following the development of the mechanical cotton picker and are concerned with various research activities related to cotton. Proposed means for solving the problem may be grouped into three principal categories as follows:

1. The development of varieties of cotton possessing growth and fruiting characteristics especially adapted to harvesting with mechanical pickers.

2. Induced defoliation of the cotton plants prior to harvesting in order to facilitate machine harvesting and to reduce the amount of extraneous matter in the seed cotton.

3. The development of more effective equipment at gins for the conditioning and cleaning of seed cotton harvested mechanically.

Preliminary studies made by the Delta Experiment Station at Stoneville, Miss., have indicated significant differences between varieties of cotton in the extraneous material harvested with the seed cotton when the mechanical picker was used. In other words, the performance of the machine picker is influenced considerably by plant type, fruiting habits, and other characteristics. To date, however, there are no conclusive data available to indicate that varieties are available or can be developed that will provide machine-picked cotton comparable in grade quality to hand-picked and that at the same time will provide satisfactory yields and fiber quality.

Studies at the Delta Experiment Station of the effect of mechanical harvesting on ginning efficiency and lint quality have shown that cotton harvested mechanically from defoliated plants average about one grade higher than for cotton similarly harvested from undefoliated plants but still a grade or more lower than for hand-picked cotton from undefoliated plants. The defoliation of the plants can be accomplished effectively by means of dusting with cyanamide at the rate of 10 to 30 pounds per acre. If applied when the youngest bolls are at least 30 days old, no difference in fiber length, strength, and yield appears to result from defoliation. It has been found, however, that earlier defoliation results in weaker fiber and some reduction in yield. The danger of application too early and the extra cost are the principal disadvantages of the defoliation procedure. Furthermore, this method is only partially effective in maintaining grade quality.

Cleaning, extracting and drying equipment of standard design now used at cotton gins fails to perform a satisfactory job of cleaning machine-picked cotton. In an effort to develop gin cleaning machinery especially adapted for removing green as well as dry leaf from machine-picked cotton, the manufacturers of mechanical cotton pickers, in cooperation with some of the gin machinery manufacturers, have designed a cylinder cleaner fitted with grids in place of the conventional screens through which leaf trash is discharged during the cleaning process prior to ginning. This cleaning unit employing heated air is used in combination with a single cylinder conveyor-type dryer and a unit extractor feeder also employing heated air as a means of drying as well as for increasing cleaning efficiency.

During the past season, observations have been made of the operation of this equipment and tests have been made to ascertain the effect of this processing on fiber quality and spinning performance. The results showed that machine-picked cotton put through the newly developed cleaning and drying processes contained considerably less leaf trash than when cleaned by conventional methods. Even with the use of this new equipment, however, the machine-picked cotton averaged more than a grade lower than the hand-picked cotton processed through conventional gin cleaning equipment. Moreover, the extensive drying action of the new system and the induced nepping of the fiber had a significantly adverse effect upon yarn strength and appearance as disclosed by the spinning tests.

In the final analysis, it appears that the successful adaptation of mechanical harvesting to the American cotton crop is likely to depend upon the development of equipment for the economical and satisfactory extraction of extraneous matter from the ginned lint after its separation from the seed and before pressing into the bales at gins. Research directed to the development of equipment to accomplish this purpose is being planned in connection with the research program of the U. S. Ginning Laboratory. Obviously, this work should be expedited as much as possible.

In the meantime, any general use of mechanical harvesting equipment for the American cotton crop would, no doubt, affect adversely the utilization of our cotton both by the domestic and foreign textile industries. On the other hand, there may be a place at present for mechanical pickers in those areas where cotton is now snapped. Presumably the use of mechanical pickers or mechanical strippers in those areas would not increase the proportions of the low grades produced.

Ginning Economies

Ginning and wrapping costs for the Cotton Belt as a whole now average more than $6.00 per bale. Although this represents a very significant item in the cotton grower's cost, it, perhaps, is not any larger than is necessary to enable the ginner to provide adequate equipment and to maintain such equipment in proper operating condition to assure a satisfactory job of ginning under existing conditions in the ginning industry.

This does not mean, however, that there are no possibilities for reducing costs of ginning. Any such possibilities are likely to be found in the direction of developing a gin plant of the type and size for optimum economy in providing ginning services.

Although the number of gin plants in the United States has declined progressively during recent years, we still have a ginning industry that, from the standpoint of size and location of individual plants, is adapted to the team and wagon era. With modern highways and modern motor transportation, it is not improbable that fewer and much larger gin plants adequately equipped for doing a good job of conditioning, cleaning, ginning, and packaging cotton, could with adequate volume, provide ginning services much more economically than is possible with gins of the present customary type. Perhaps such gin plants could advantageously be integrated with cottonseed crushing and cotton warehousing and marketing. The engineering and economic aspects of facilities of this type, however, will require considerable research before definite recommendations can be made.

Economies in Marketing

The handling of cotton in marketing channels is not by any means devoid of possibilities for effecting reductions in the spread between prices received by growers and prices paid by cotton mills. Perhaps the most promising opportunities for reducing marketing costs will be found in the integration of some of the services incident to the marketing of cotton with ginning services at gin plants of the type previously indicated.

Except for export cotton, the final bale package can be prepared more economically at gins than under the present system of turning out low-density bales at gins which have to bear the expense of compression

at compresses and the extra handling incident to that process. Research recently completed has indicated the mechanical and economic feasibility of gin presses capable of producing bales of standard density (22 pounds per cubic foot) which would obviate the need for recompression of the bales for domestic shipment. When material for the construction of presses of this type is again available, gins in the central and western parts of the Cotton Belt could advantageously install such press equipment.

Present methods of sampling cotton bales leave much to be desired from the standpoint of providing adequate and authentic samples as a basis for the classification and sale of cotton. The traditional method of sampling used by the cotton trade, which consists of cutting samples from two sides but occasionally from only one side of the bales, fails in many instances to provide a true cross section of the cotton contained in the bales because of variations in the quality of the cotton contained within individual bales. Furthermore, this method of sampling results in the mutilation of the bale covering and subjects the bale contents to damage and waste. The customary procedure of drawing new samples with each change, or prospective change of ownership, not only constitutes a significant item in the cost of marketing but probably results either directly or indirectly in diminishing the weight of bales approximately 3 pounds each between the time the cotton is placed in marketing channels and the time it reaches consuming establishments.

Research and developmental work now practically completed has provided equipment for the automatic sampling of cotton bales while they are being formed at gins. This equipment, which can be used with any standard gin equipment and which has been tested on a commercial scale during the past ginning season, provides adequate and authentic samples that could be used satisfactorily throughout the entire marketing chain. A public service patent has been obtained for this sampling device. The general installation of sampling equipment of this type when coordinated with marketing procedures, would reduce marketing costs approximately $1.00 per bale.

It appears inevitable that as production is standardized by variety in sizable areas, marketing channels will be shorter and more direct. This should appreciably reduce the spread between farm prices and mill prices.

Processing Improvements

Cotton manufacturing was one of the first of the mechanized industries that ushered in the Industrial Revolution about a century and a half ago. In the meantime, however, that industry has not kept pace with other industries in labor-saving devices such as automatic machines and assembly-line methods. The basic principles of cotton manufacturing have not been changed significantly for several decades although a number of improvements

in machinery and processes have been made. The 15 or more separate processes involved in transforming raw cotton into woven fabrics appear to place the cotton industry under a heavy handicap in comparison with competing products involving fewer processes and less human labor. The cotton textile industry has hardly scratched the surface in research to develop more efficient and economical processes. Progress in that direction would, no doubt, do much to assure the future position of cotton as a textile material.

Readjustments in Prices

It is now quite obvious that the prices at which American raw cotton and the products made from it are available will determine, in large measure, the extent of its post-war market. If substantial reductions can be made in production, ginning, and marketing costs, readjustments in prices of American cotton in relation to prices of competing materials would be possible without affecting adversely the incomes of cotton growers. Whether such reductions in costs would be reflected in readjustments in market prices would depend upon policies with respect to price support through governmental loans and other means.

The subject of price-support measures is assigned to another committee and will not be covered in this report.

SUMMARY AND CONCLUSIONS

Because of the wide range of its uses, cotton is thrown into competition with a variety of materials, including all the natural and synthetic textile fibers as well as paper, leather, rubber, wood, and metal. Only small quantities of cotton have been displaced as a result of competition from some of these materials in recent years, but other of these materials, notably synthetic fibers and paper, have displaced large quantities of cotton in certain uses during this period.

Continued improvements have been made in the quality of rayon, the principal synthetic fiber, during the years since World War I. At the same time, prices have been greatly reduced until rayon staple fiber, for instance, currently sells for only 2 cents more per pound than Middling, 1-inch cotton. As a result, rayon today is in a better position to compete with cotton than ever before. Until recently, rayon competed with cotton

almost exclusively in apparel and household products, where appearance and style are competitive factors of greatest importance. It now is entering industrial uses, however, with tire fabrics the most important application to date. But in uses where durability combined with low price are factors of greatest importance, rayon is not at present able to compete successfully with cotton. Much of the field now supplied by cotton comes within this category.

Production of paper products that compete with cotton, such as bags, towels, gummed paper tape, napkins, and handkerchiefs, has increased rapidly during the last few years. Although it can be expected that there will be little further displacement of cotton by paper in some uses, technological progress in the use and improvement of paper continues and further displacement in other uses is likely. This should have very little net effect, however, on demand for cotton during the first year or two of the post-war period.

During the war, cotton has replaced jute to a considerable extent in bags and to a lesser extent in other products such as wrapping materials and bagging for covering cotton bales. Cotton, however, has failed to prove superior, relative costs considered, for the great majority of these uses and most of its gain can be considered temporary. Nevertheless, consumption of cotton in this group of uses can be expected to decline only gradually, since the need for bags, by far the most important item, should continue at high levels for sometime after the end of the war. Some permanent gains for cotton should result in applications where cotton has conclusively demonstrated its value.

For cotton to compete successfully with paper and jute, it is essential that cotton products should offer the consumer at least equal value per unit of cost in comparison with corresponding jute or paper products. In this connection, it should be noted that cotton prices act, to some extent, as a ceiling on jute prices, since cotton can be used for practically all purposes for which jute is used. With due consideration to this factor, the competitive position of cotton in uses where it competes with jute and paper can be improved by steps such as (1) development of lower-cost processing methods, (2) use of better merchandising methods -- particularly for cotton bagging, (3) closer adaptation of cotton products to individual use requirements, and (4) emphasizing the higher re-use and salvage values of cotton products.

Displacement of cotton in individual uses results in very little immediate change in the total demand for cotton. Even if cotton were completely displaced in its most important single use, tire fabrics, there would be a decline of less than 8 percent in the total domestic consumption. At the same time, losses in some uses may be counterbalanced by gains in others, so that there is little net effect on the total consumption. As an example, recent increases in the use of cotton in plastics and for insula-

tion tend to offset losses as a result of competition from paper and rayon. In general, technological changes affecting use of cotton take place slowly and their full effect is felt only after a period of years.

From the standpoint of technological factors, cotton, if selected by variety for specific uses, can, with very few exceptions, provide comparable results with substitute textile materials for the normal range of uses for which cotton customarily is used.

Taking the above and other factors into consideration, it can be concluded that there will be no marked change in the demand for cotton during the next year or two, compared with the present demand, as a result of competition from other materials. Over a longer period of years, the opposite may emphatically be true. For instance, it can be expected that inroads made since the beginning of the war by competitive materials into important uses of cotton, such as in tires and in bags, will be felt more keenly when the wartime demand for these products subsides. Much depends, of course, on steps taken to assure cotton's competitive position. In this connection, it is essential that cotton should be priced as favorably as possible compared with competitive materials, that research should be conducted and other steps taken to improve the physical and chemical properties of cotton products for various uses, and that the public should be kept fully informed relative to the advantages and adaptability of cotton by advertising and other promotional activities.

Whether cotton can continue to compete on a price basis with substitute materials for the various uses for which cotton is adapted will depend upon the extent to which reductions can be made in costs of production, ginning, marketing, and processing without adversely affecting incomes of cotton growers or the quality of the services performed by other groups in the cotton industry. Indications are that substantial reductions can be made which, if accomplished, would enhance very materially cotton's competitive position.

Obviously, price-support policies as applied to cotton should be given careful consideration in relation to the problem of maintaining cotton's competitive position.

RECOMMENDATIONS

In order to maintain cotton's markets in uses threatened by competition from other materials, the following recommendations are made:

1. That research be intensified to provide means for improving the physical and chemical properties of cotton products for specific uses.

2. That steps be taken by appropriate Federal and State agencies to expand the program of standardized production of improved varieties of cotton on a single variety area basis; also that an adequate system be established for safeguarding the identity of individual bales of cotton by variety thereby making possible the procurement by manufacturers of cotton of specific varieties most suitable for specific uses and the reduction in marketing costs that would follow elimination of duplication of sampling and classification services.

3. That research be intensified to explore possibilities for reducing costs of producing, ginning, marketing, and handling cotton as a means of improving its competitive position from the standpoint of price without affecting adversely the incomes of cotton growers.

4. That appropriate steps be taken to encourage the initial adaptation of cotton to new and promising fields of uses.

5. That the public be kept informed by appropriate means of the advantages and adaptability of cotton.

HEMP

PRE-WAR SITUATION WITH RESPECT TO THE DOMESTIC HEMP INDUSTRY

For a number of years prior to the current war, only a relatively small amount of hemp was consumed in this country. Domestic production supplied about one-third of commercial needs and imports from Italy supplied most of the remainder. Although at one time or another hemp fiber has been used for many purposes, its use in recent pre-war years was limited to a few so-called specialties, such as cores for wire rope, marine lines and yarns, upholsterers twines, and strong wrapping twines. A little was used for oakum and some for mixing with other fibers.

Domestically produced hemp had been unable to withstand competition from such fibers as jute, cotton, and the hard fibers such as sisal, henequen, and abaca. Prior to the war, hard fibers had completely replaced hemp in ropes, cables, and coarse cordage, because they were better adapted to these purposes and could be obtained at relatively cheaper costs to manufacturers.

Data with respect to hemp production, imports, and total supplies available for consumption in the United States from 1935 to 1943 are shown in table 33. For the pre-war period 1935 to 1939, an average of only about 1,250 acres was grown annually. This acreage was mostly in Wisconsin and Kentucky. Fiber production averaged slightly more than one million pounds, representing 38 percent of the total supply available for consumption. In 1939 there were five processing plants in operation in this country, one in Kentucky and four in Wisconsin. These plants had capacity for processing the production of about 3,500 acres.

WAR DEVELOPMENTS

With the coming of the war, hemp imports from Italy were cut off. Supplies of the hard fibers for use in the cordage industry were also cut off from two of our main sources, the Philippines and the Netherlands East Indies. Therefore, hemp became a strategic war crop in the United States. It was thought advisable to increase production of this fiber to provide for its regular use and to build a stock pile that could be substituted for cordage fibers in the manufacture of durable twine and ropes, should the need arise.

Table 33. - Hemp acreage, production, imports and consumption, United States, 1935-43

Year	United States 1/			Imports for consumption 2/		Total (Domestic production and imports)	
	Acreage	Production					
	Acres	1,000 pounds	Pct.	1,000 pounds	Pct.	1,000 pounds	Pct.
1935	700	612	22.8	2,076	77.2	2,688	100.0
1936	1,400	1,015	37.6	1,687	62.4	2,702	100.0
1937	1,300	1,040	37.4	1,743	62.6	2,783	100.0
1938	1,390	1,246	48.9	1,303	51.1	2,549	100.0
1939	1,440	1,282	45.8	1,519	54.2	2,801	100.0
Average 1935-39	1,246	1,039	38.5	1,666	61.5	2,705	100.0
1940	2,070	1,665	71.5	663	28.5	2,328	100.0
1941	7,400	7,410	100.0	3/	-	7,410	100.0
1942	14,500	13,922	74.3	4,803	25.7	18,725	100.0
1943	145,900	135,251	99.5	703	.5	135,954	100.0

1/ Estimated from unpublished data from official sources.
2/ Compiled from reports of United States Tariff Commission and from foreign commerce statistics of the United States.
3/ Possibly small amount from South America but data not available.

Sources: Bureau of Agricultural and Industrial Chemistry. Bureau of Agricultural Economics.

Expansion in domestic hemp acreage began in 1940. During that year over 2,000 acres were grown and production amounted to 1-1/2 million pounds of fiber. Through concerted effort on the part of the trade and various governmental agencies, the acreage was increased to about 14,500 acres in 1942 and production increased to 14 million pounds.

In 1943, the Commodity Credit Corporation contracted with hemp growers to pay the following schedule of prices for their product delivered at mill:

$50.00 per ton for Class 1 straw
40.00 per ton for Class 2 straw
35.00 per ton for Class 3 straw
30.00 per ton for Class 4 straw

These prices were deemed sufficient to make the growing of hemp profitable to the point that increased acreage would result in areas where it could be grown satisfactorily. The Commodity Credit Corporation also assisted producers in procuring planting seed and in making available machinery for harvesting the increased production. About 146,000 acres were planted in 1943 and production is likely to exceed 135 million pounds. Apparently, this production will bring stock piles to a satisfactory level. The 1944 goal has been reduced to 60,000 acres.

To provide sufficient processing facilities for handling the increased production of hemp fiber, the Defense Plant Corporation made provisions for the construction of 42 hemp mills. This brings the total to 47 since there were already 5 plants in operation. The agreement between Defense Plant Corporation and Commodity Credit Corporation provided for the lease of these plants to War Hemp Industries, a corporation set up to operate the plants for use in processing hemp fiber for war needs. When these needs no longer exist, the plants are to be returned to Defense Plant Corporation for disposition. It is estimated that the 47 plants will have sufficient capacity to handle production from 175,000 to 200,000 acres, which was estimated to be the maximum required to supply war needs. Following are numbers of plant locations by States: Illinois 11; Iowa 11; Minnesota 11; Wisconsin 10; Indiana 2; and Kentucky 2. The major portion of domestic hemp was produced in these States in 1943.

PROBABLE POST-WAR DEVELOPMENTS

When foreign commerce is reestablished it is highly probable that the United States will commence importing supplies of various types of fibers for use in the cordage industries. Consequently, hemp will, no doubt, drop back into its pre-war uses. As has been pointed out, the relatively high cost of producing hemp domestically, together with the fact that it is not as desirable as are other fibers for the cordage industry and is much higher in price, is almost certain to force it completely from the cordage field again. In 1939, domestically produced hemp was quoted at about 16 cents per pound in comparison with 12 cents for imported hemp, 5.7 cents for jute, 3.7 cents for henequen, 3 cents for ixtle, and 4 cents for sisal (table 34). Obviously, domestic hemp could not compete for use as cordage at these relative prices.

The 42 hemp mills that were built by Defense Plant Corporation and leased to Commodity Credit Corporation, which in turn subleased them to War Hemp Industries, will, according to contract, be turned back to Defense Plant Corporation after war needs for hemp have ceased. In the event production of domestic hemp is maintained at a higher rate than during the pre-war period, some of these mills will, no doubt, be sold to private industry for continued operation. Some may be held in stand-by condition for any possible exigencies that may arise. Others will probably be disposed of, since it is doubtful that they can be converted to other uses. Unneeded plants could, perhaps, be sold to Italy or other hemp-producing countries under the post-war rehabilitation program.

SUMMARY AND CONCLUSIONS

The domestic hemp industry has been revived as a war measure. At the close of the war, United States production is likely to exceed imports during the pre-war period. The United States, however, is at a great disadvantage in hemp production and the present rate of production is possible only under governmental encouragement. The domestic hemp industry could be maintained at the present scale in the post-war period only through a high protective tariff or payment of subsidies to producers. It is doubtful if such a program could be justified.

Table 34. - Prices per pound of specific vegetable fibers, United States, 1935-43

Year	Hemp		Jute	Henequen	Ixtle DLF	Manila hemp 5/	Sisal 6/
	Domestic 1/	Imported 2/	Imported 3/	Imported 4/	Imported	Imported	Imported
	Cents	Cents	Cents	Cents	Cents	Cents	Cents
1935 . .	12.5	12.3	4.3	4.1	2.8	5.9	4.0
1936 . .	12.0	13.0	4.3	6.2	3.5	8.5	6.2
1937 . .	12.0	12.6	4.6	5.7	3.5	10.2	5.7
1938 . .	11.5	11.7	4.3	4.1	2.5	6.9	4.2
1939 . .	16.0	12.1	5.7	3.7	3.0	6.5	4.0
1940 . .	17.4	16.1	6.1	4.1	3.2	6.7	4.0
1941 . .	24.6	19.2	6.7	3.9	2.6	9.1	4.2
1942 . .	26.5	-	7.4	-	-	10.6 7/	5.9 7/
1943 . .	24.3	-	7.7	-	-	-	-

1/ Estimated average mill prices for fiber. Bureau of Agricultural Economics.
2/ Estimated average import value. Bureau of Agricultural Economics.
3/ Prices for raw jute are for medium grades at New York. Bureau of Agricultural Economics.
4/ Prices of best grades, C.I.F. New York; John Z. Williams, U. S. Consular Service; Some Fibers and Fossibilities of Their Development in Western Hemisphere, published in September 1943 issue of Cordage Magazine.
5/ Average mid-month quotations at New York Fair, current shipments, as reported by Daily Mill Stock Reporter.
6/ Average mid-month quotations, C.I.F. Gulf Ports, as reported by Daily Mill Stock Reporter.
7/ Prices for January and February only.

Prices are not always for comparable qualities.

FLAX FIBER

PRE-WAR SITUATION WITH RESPECT TO THE DOMESTIC INDUSTRY

Consumption of flax fiber is of minor importance in the United States as compared with other fibers. It has been limited almost entirely to what is termed coarse goods -- fabrics and other articles made of coarse yarns (60s or coarser) for such uses as towels, fishing lines, twine, and thread. The paper industry also uses varying amounts of the fiber. All fine linens are imported from European countries. No equipment for spinning yarns for the fine linens is in place in this country. Neither are there sufficiently trained craftsmen available for operating it.

The production of flax fiber in this country has been restricted largely to the Willonette River Valley in Oregon for a number of years; however it has been grown at one time or another in other areas. Domestic production normally supplies but a small percentage of our commercial needs, and imports, mainly from the European countries, supply the remainder. Table 35 shows flax production, imports, and the amount available for consumption from 1936 through 1943. During the pre-war period 1936-39 an average of only 3,500 acres was grown annually in the United States. Domestic production averaged around 883,000 pounds of fiber, or 8 percent of the total supply. Six processing plants located within the producing area and operated by farmers' cooperatives were available for handling the crop. The 12 mills for spinning the fiber were located mostly in the Eastern States.

WAR DEVELOPMENTS

When shipping space became restricted by the war, domestic flax found a better market than had normally been the case and production increased materially. In 1940 production from the 7,300 acres was 1.7 million pounds, or 15 percent of total supply in this country. The peak of fiber flax acreage was reached in 1942 when 18,000 acres were planted. Production that year was 7.4 million pounds, or 38 percent of total supply for that year. Beginning with the 1942 crop, the Commodity Credit Corporation made arrangements for farmers' cooperatives to purchase members' flax fiber at $30.00 per ton of straw for stock-pile purposes. Most of production from the 1942 and 1943 crops was purchased under this

arrangement, but two additional processing plants were constructed to handle increased production. In 1943, acreage was reduced and in 1944, further curtailment is anticipated. From all evidence, production at the rate of recent years plus amounts available from South America and other sources can provide more than enough flax fiber for any emergency that may occur.

Table 35. - Fiber flax: Acreage, production, imports, and consumption, United States, 1936-43

Year	United States: Acreage 1/	United States: Production 2/		Imports for consumption 3/		Total (domestic production and imports)	
	Acres	1,000 pounds	Pct.	1,000 pounds	Pct.	1,000 pounds	Pct.
1936	2,540	1,024	7.7	12,300	92.3	13,324	100.0
1937	2,750	865	6.1	13,300	93.9	14,165	100.0
1938	3,880	524	16.8	2,600	83.2	3,124	100.0
1939	3,900	1,120	7.9	13,100	92.1	14,220	100.0
Average 1936-39	3,518	883	7.9	10,325	92.1	11,208	100.0
1940	7,300	1,723	15.1	9,700	84.9	11,423	100.0
1941	11,000	4,765	43.5	6,200	56.5	10,965	100.0
1942 4/	18,000	7,400	38.5	11,800	61.5	19,200	100.0
1943 4/	12,000	4,000	32.0	8,500	68.0	12,500	100.0

1/ Acreage as reported by Crop Reporting Board, United States Department of Agriculture.
2/ Fiber estimated at 10 percent of straw production.
3/ Compiled from reports of United States Tariff Commission and from Foreign Commerce and Navigation.
4/ Largely estimated but believed to be reasonably correct.

Source: Bureau of Agricultural Economics. Bureau of Agricultural and Industrial Chemistry.

PROBABLE POST-WAR DEVELOPMENTS

It is doubtful if flax fiber will ever be of great importance in this country. Production could possibly be increased to the point where all domestic needs could be supplied from it. Certain difficulties may make this impracticable. In the first place, fiber flax requires more care than most crops in both growing and harvesting and its return per acre is relatively small when compared with other crops. Perhaps the most important reason is that other fibers are available at lower prices. Also it is doubtful if domestic flax can compete with imported flax from a cost standpoint to any greater extent than it has in the past. Therefore, when governmental encouragement of the crop is discontinued, flax production will no doubt drop back to its approximate pre-war status.

SUMMARY AND CONCLUSIONS

Although flax fiber is not considered a war necessity to the same degree as some other fibers, it was believed advisable to increase production to the point where the United States could be more nearly self sufficient in the event outside supplies were cut off or materially restricted. To accomplish this, prices have been supported by the Commodity Credit Corporation at an attractive level since 1942. Domestic production plus quantities received from South America or elsewhere have not only supplied current needs but have built up stockpiles against any exigency within reason that may arise. Whether such stockpiles are to become unduly large and burdensome in the post-war period will quite obviously depend upon future policies with respect to support prices.

WOOL

WARTIME DEVELOPMENTS

Domestic production of wool increased from 428 million pounds (grease basis) in 1939 to a new record of 459 million pounds in 1942 (table 36). This increase is attributable to relatively high wool and lamb prices and favorable conditions with respect to production. Subsequent to 1942, however, wool production has declined somewhat because of labor shortages and relatively high production costs in relation to ceiling prices for the products.

Consumption of apparel wool has increased to record levels since the outbreak of the war, while consumption of carpet wool has declined sharply (table 37). Because of the large military requirements and the possibility that submarine warfare might cut off foreign sources of supply, imports were increased greatly and large stocks of apparel wool were accumulated. During the pre-war years, stocks of wool on hand in this country on January 1 of each year usually were below 250 million pounds. As of January 1, 1944, stocks were more than 500 million pounds. Although these stocks are probably the largest on record, they are less than the current rate of consumption.

Average prices received by growers of domestic wool increased from 22.3 cents per pound (grease basis) in 1939 to 41.6 cents in 1943 (table 38). The ceiling prices placed on both domestic and imported wools in December 1941 maintain a disparity in prices of the two growths which previously had developed. Because of this, very little domestic wool has been used in fabrics for civilian use. Domestic wool has been used for military goods only because of policy with respect to Government purchases. With the decline in military orders in 1943, the demand for domestic wool declined sharply.

In order to protect domestic growers, a Government purchase program was provided in April 1943. Under this program, practically all domestic wool is now purchased by the Commodity Credit Corporation at ceiling prices. The wool is available for purchase also at ceiling prices.

Prices of foreign apparel wool during the war years have been considerably lower than the ceiling prices at which domestic wool is bought and sold by the Commodity Credit Corporation. In April 1944, fine Australian wools were available in Boston at $1.02 to $1.05 per pound, scoured basis, as compared with $1.17 to $1.21 for a comparable grade of domestic wool.

Table 36. - Wool: United States production, exports, imports, and stocks as of December 31, 1935-43

Year	Apparel wool			Carpet wool	Total stocks 2/
	Production 1/	Exports	Imports for consumption	Imports for consumption	
	Thousand pounds	Thousand pounds	Thousand pounds	Thousand pounds	Thousand pounds
1935	427,531	20	41,984	158,477	290,805
1936	419,063	16	110,712	143,276	302,820
1937	423,654	68	150,160	172,091	334,558
1938	425,680	1,343	30,811	71,908	263,749
1939	428,216	179	98,194	144,875	215,262
1940	436,564	456	222,983	134,691	229,132
1941	456,368	3/	3/	3/	246,156
1942	459,073	3/	3/	3/	463,728
1943 4/.	448,000	3/	3/	3/	532,000

1/ Includes both shorn and pulled.
2/ Data include apparel and carpet wool but exclude wool afloat to the United States.
3/ Not available.
4/ Preliminary.
Agricultural Statistics, 1943. United States Department of Agriculture.

Table 37. - Wool: Mill consumption in the United States, by growths, 1935 - 1943 1/

Year	Apparel wool				Carpet wool (all foreign)	
	Total (scoured basis)	Greasy shorn basis			Scoured basis	Greasy shorn basis
		Domestic	Foreign	Total		
	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds	Million pounds
1935	319.0	709.5	38.9	748.4	98.5	141.7
1936	299.8	557.1	109.3	666.4	106.3	152.5
1937	274.2	421.3	158.2	579.5	106.6	152.7
1938	219.6	475.1	38.8	513.9	64.9	93.0
1939	293.1	593.0	80.9	673.9	103.4	149.2
1940	309.4	526.7	155.8	682.5	97.9	137.6
1941	515.7	532.9	488.6	1,021.5	132.3	192.4
1942	571.4	567.7	546.4	1,123.1	43.9	61.3
1943 2/ . . .	591.9	464.4	644.7	1,109.1	32.2	43.9

1/ Compiled from reports of the Bureau of the Census.
2/ Preliminary.

Table 38. - Wool: United States average farm prices and Boston prices, scoured basis, Territory Grade 56s, 1935-43

Year	Farm price	Boston price
	Cents per pound	Cents per pound
1935	19.2	64
1936	26.9	80
1937	32.0	87
1938	19.1	59
1939	22.3	69
1940	28.3	80
1941	35.5	91
1942	40.1	103
1943 1/	41.6	104

1/ Preliminary.

Agricultural Statistics. U. S. Department of Agriculture.

COMPETITION OF SYNTHETIC FIBERS

Of the synthetics, the various casein fibers most nearly approach the physical properties of wool. The only one of these of commercial importance at present is "Aralac." Aralac now sells at about 64 cents per pound, which is substantially lower than clothing wool. The dry strength of Aralac, however, is slightly lower than wool and the wet strength is decidedly inferior. This being the case, it is not expected that Aralac will replace wool to any great extent unless or until its properties are further improved.

It is not possible, at present, to forecast the future of the various casein fibers as competitors of wool because they have been used only a short time and in relatively limited quantities so that their adaptability has not yet been demonstrated.

Rayon staple fiber is being used to some extent as a substitute for wool. The versatility and adaptability of staple fiber for blending with other fibers has made possible the development of a large variety of fabrics with style effects and designs not previously obtainable. Because of this factor, it is probable that the net effect of the use of this fiber on wool consumption to date has been negligible. Although some wool has been replaced for certain uses, new fabrics involving the blending of wool with staple rayon have provided offsetting market outlets for wool.

With rayon staple fiber selling for about 25 cents per pound in comparison with about $1.20 per pound for fine-scoured wool, the incentive for substitution is obvious. The largest quantity of rayon staple fiber used in worsteds in any year to date was 10.6 million pounds in 1937. In recent years, the quantities used have been substantially below that figure. Approximately 16 million pounds of rayon waste was used in woolens in 1942. A part of this, however, represented the replacement of other fibers usually blended in woolens rather than substitution of that quantity of wool.

MARKETING

The Commodity Credit Corporation purchase program, under which practically the entire domestic wool production is being handled, provides for the use of existing marketing agencies acting as agents of the Corporation in conducting transactions with growers. This assures the maintenance of existing marketing facilities.

The Commodity Credit Corporation's agreement with marketing agencies provides that producers shall receive a copy of the official appraisal committee's certificate, which shows the grade, weight, shrinkage, and approximate value of the wool in each instance. This is a departure in wool marketing and will, no doubt, be insisted upon by producers in the post-war period.

TECHNOLOGICAL DEVELOPMENTS IN PROCESSING

In the opinion of leaders in the wool textile industry, the replacement of worn-out and obsolete equipment will be one of the most important of the immediate post-war problems of the industry. This situation will, no doubt, provide an opportunity for modernizing the processing of wool by the installation of improved machinery that will simplify wool manufacturing and finishing processes and thereby reduce costs. Improved wool processing machinery reported to be available after the war covers the entire range from opening and blending equipment to that used in finishing. The commercial possibilities of some of this machinery, however, has not yet been demonstrated.

SUMMARY AND CONCLUSIONS

The unprecedented stocks of wool that have been accumulated in this country during the war years pose the principal problem of marketing the domestic wool crop during the immediate post-war years. Even with little or no imports, it would probably take several years for the excess of domestic consumption over domestic production to reduce stocks to normal proportions.

With foreign wools available to the domestic woolen textile industry at prices substantially below the present Commodity Credit Corporation purchase and sale prices, domestic wool is not being used except when required as a condition of Government contracts. Under present circumstances, the Government would have to absorb a loss of about 15 cents per pound to assure the use of domestic wool for civilian uses.

There is no immediate prospect of appreciable displacement of wool by synthetic fibers. Such displacement as has taken place to date has probably been offset very largely by the expanded use of wool for blending with synthetic fibers in new types of fabrics.